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Contents.

	PAGE
Index to Advertisers	13
Notes and Comments	285
Melting Non-Ferrous Metals in an Open-Hearth Furnace	286
Automobile Steels	287
The Co-operation of Scientific and Industrial Research in the Iron Foundry	288
Heat Treatment of Copper Alloys	291
X-Rays and their Industrial Applications	296
Some Experiences of Cupola Practice	297
The "Wadkin" Mechanical Wood Worker	301
Health in Brass Foundries	302
Reactions in Gas Producers	302
Trade Talk	303
Personal	304
Company News	304
Deaths	304
Gazette	304
Iron and Steel Markets	306

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NOTES AND COMMENTS.

Automobile Castings.

The foundry industry recently received a further indictment, but this time the section attacked was automobile castings, the occasion being a lecture before the Sheffield Branch of the Institution of British Foundrymen, by Mr. J. B. Hoblyn, who is attached to the motor industry. He stated that perhaps 25 per cent. of the castings supplied to the automobile trade were defective. If such a statement is correct, the question naturally arises, what is the percentage of wasters as they leave the mould? Obviously, it must be considerably higher than the returns made by the users. As we are always anxious for a constructive policy to be evolved, we would advise all foundries to be collecting data, so that when the British Cast-Iron Research Association becomes active, each foundry will be in a position to say that the defect giving the most trouble is of such and such a nature. Should all the foundries who propose being members of the Association pursue this course, then a flying start would be assured. But, on the other hand, should no such data be available when the time comes and questionnaires are received, the ineffectual answer will be "we will ask our costing department." As we have previously asserted, the collection of data will in itself solve many problems, which in a shop without such a system appear insoluble.

Foundry Associations.

We have recently applied for membership of French Foundry Association, and were surprised to learn that "on the death of a member the others are required to pay 3½ francs, of which the widow receives 3 francs, the total amounting at the present time to about 1,400 francs." In all other respects, the constitution of the Society closely resembles that of the Institution of British Foundrymen. Its members are mainly foundry managers and foremen, and to the thrifty French a sum of 1,400 francs (about £56 at a normal rate of exchange) does not represent much, and we feel certain that the inclusion of such a rule is to interest the workman in the educational side of his work. Though inducements to join technical societies should not be necessary, they might have the advantage of instilling into a worker an incipient interest which, under cultivation, might produce a brilliant asset to the foundry industry. It might be argued, however, that the inclusion of insurance schemes into technical societies would keep out some of the best men, but, happily, in the foundry industry at least, we are surprisingly free from snobbishness. The only objection we can see is the possible relegation to a secondary position of its fundamental character as an educational institution.

The British Cast-Iron Research Association.

The Council have arranged to hold meetings at Birmingham, Leeds, and Glasgow at an early date to lay before the ironfoundry industry the work of the Association. Lord Weir will take the chair at the Birmingham meeting, and will make an important speech upon the position of the cast-iron trade.

The Foundrymen's Competition.

We hope to publish in our issue of April 7 the result of the competition. We are pleased to announce that Mr. Matt. Riddell, President of the Institution of British Foundrymen, has promised to help us should difficulty arise in the final decision.

NICKEL BRASSES.—The work of M. Leon Guillet on the subject of nickel brasses is summarised by the "Chemical and Metallurgical Engineering" as follows:—The results indicate the great value of nickel in the manufacture of low-copper brasses. From the industrial point of view, this study describes some alloys of exceptional qualities possessing ultimate strength up to 40 tons per sq. in., with 20 per cent. elongation and a resiliency of 8 to 10 kg.-m., very interesting variations in colour from white to gold yellow, and a high resistance to atmospheric corrosion. It can be expected that nickel is destined to play the same important rôle in the manufacture of copper alloys as it does in that of steels. It is to be noted, however, that brasses with very high nickel contents can exhibit good microstructure ($\alpha + \beta$), yet not have any valuable special property.

Melting Non-Ferrous Metals in an Open-Hearth Furnace.

To dispense with the use of crucibles when melting non-ferrous metals is to eliminate a serious factor in the working costs of the foundry, and if at the same time the manual labour incidental to the melting, as compared with the crucible, can be reduced, a corresponding increase in output efficiency must necessarily result. Hitherto the crucible has held its own, even in the largest foundries, because, all things considered, it was perhaps the most economical proposition available, the heating of the crucible furnace being alike simple and comparatively inexpensive; indeed, the whole system may be said to have been determined by the method of heating. Men and managers were familiar with melting in the crucible, and before they could be expected to depart from a system which had been thoroughly proved, it was necessary to satisfy them that the substitute was not only commercially and practically sound, but also that its operation called for no higher skill than is usually available in the foundry melting shop.

Quite recently the same set of factors governed the melting of special qualities of steel in the crucible; it was, however, only necessary to prove the commercial possibilities of the electric furnace, for its adoption to become fairly general in works producing special steels.

The furnace shown in Figs. 1 and 2, and which was recently seen in operation at the Caldervale Works, Bellshill, N.B., of Messrs. Burdons, Limited, the builders of the furnace, may well become the prototype of an equally revolutionary change in the non-ferrous metal foundry.

The construction of the furnace is so simple that it will call for little explanation, other than furnished by our illustrations.

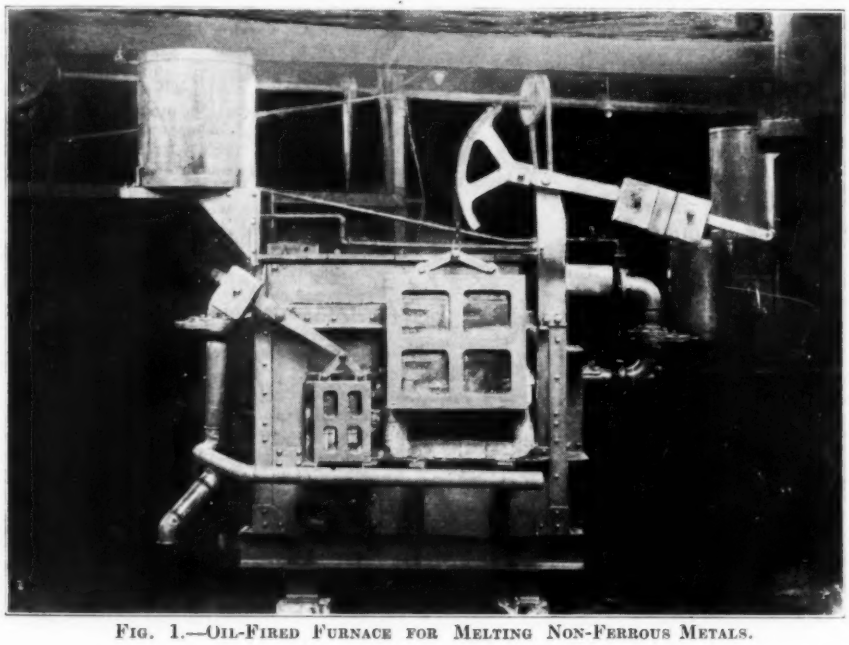


Fig. 1.—Oil-Fired Furnace for Melting Non-Ferrous Metals.

It will be seen that the interior of the furnace is in the form of a well, designed to empty itself through the spout, which is placed on the opposite side of the furnace to the charging door.

Air is supplied by a motor-driven fan at about 12½-in. water gauge, the air main passing through the crown of the furnace, so that it is intensely pre-heated before delivery into the carburetter, where it meets the oil which flows by gravity from the elevated tank. Such ordinary oil fuels as creosote or tar oils flow readily at ordinary temperatures, but provision is made by a by-pass pipe from the hot-air main to heat up the oil when required. The heart of the firing system lies in the carburetter, which consists essentially of an inner and outer annular chamber; of these chambers the inner is fitted with a series of vanes set clockwise, and the outer with a series of vanes set counter-clockwise. The oil is led into the inner chamber, and the blast enters both chambers. The air in the inner chamber, by its intense heat and whirling motion, naturally breaks up the oil into very minute particles, but as this leaves the nozzle

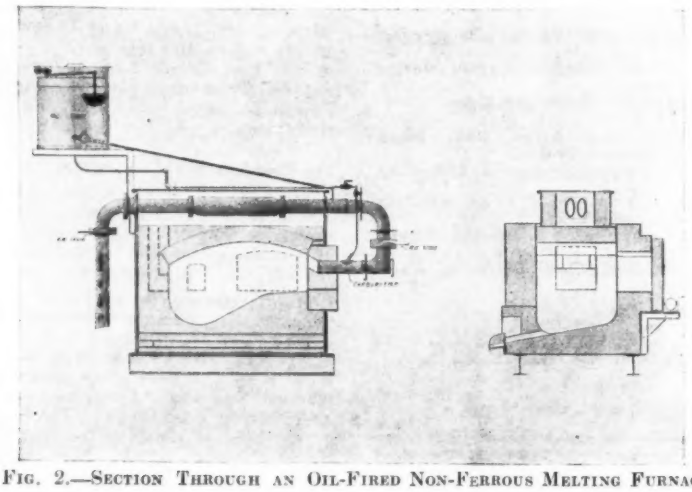


Fig. 2.—Section Through an Oil-Fired Non-Ferrous Melting Furnace.

of the chamber it meets a strong current of heated air which is whirling in the opposite direction, so that the oil enters the furnace chamber as a very fine vapour, actually indeed a gas. The disposition of the carburetter relative to the arch of the furnace is such that the burning gases, when the furnace is empty, circle completely round the bath and chamber. The furnace is ready for melting a charge within half an hour of starting up from cold, a melting temperature is reached in considerably less time than this, but in the time specified the bath has reached incandescent heat. It should be particularly noted that no cold metal is ever put into the bath. The cold metal is charged on to the bridge above the bath into which it runs as it melts down.

We are able to publish the results of tests made on this furnace by a Scottish firm of metal melters, which are shown in Table I.

We understand that portable furnaces of this type are being supplied from 100 lbs. capacity up to 1,500 lbs. capacity. Where several tons of metal require to be melted at a time, furnaces are built up in position and a special heating equipment fitted thereto.

TABLE I.—*Showing results of tests given by an oil fired, non-ferrous melting furnace.*

Material*	Weight charged in lbs.	Total time of melting in mins.	Total consumption of oil in Galls.	Oil consumption per 100 lbs. of metal melted in Galls.	Weight of metal tapped in lbs.	Yield per cent.
Copper*	573	66	5.98	1.04	569.5	99.39
Gun-metal*	573.5	40	4.11	.72	559	97.47
Light copper scrap	560	51	5.32	.95	549	98.05

* Raw materials—small ingots.

Automobile Steels.

An interesting lecture was recently given by Dr. W. H. Hatfield before the Institution of Automobile Engineers on the result of some experiments he had carried out on fatigue tests on automobile steels. A number of interesting points arose in the discussion upon his Paper on "The Most Suitable Steels for Automobile Parts" last year. Perhaps the most important of these was the question of the true elastic range of the steels dealt with.

In replying to the discussion last year, the author intimated that they had been conducting at the Brown-Firth Research Laboratories for some considerable time an investigation designed to establish the actual fatigue range of the different steels.

The machine employed was the Wöhler rotary bend test machine. The speed of rotation was 1,500 r.p.m., and the procedure during the experiments consisted of modifying gradually the load on the bar until a load was attained which the bar would carry without rupture for 10,000,000 revs. It would thus be seen that the test-piece which stood 10,000,000 revs. would be under test day and night for practically five days. Some test-pieces were run for a much longer period, and the fact that one such test-piece broke after 13,000,000 revs. showed that, while being an excellent test, it by no means indicated the capacity of the material for running to infinity.

Following closely on Wöhler's own work, the wrought iron was at first loaded to a stress of 15 tons per sq. in., and rupture occurred after 644,800 revs. The load was then reduced to 14 tons and subsequently to 12 tons, and at the latter figure a high value for resistance had apparently been reached. The experiments were commenced with wrought iron, owing to its high capacity for plastic deformation, and it was thought that it would be of considerable interest to see how it behaved; hence the fact that after approaching what appeared to be the elastic range of the material some much heavier loadings were tried. The maximum stress on the material was proved to be 22.34 tons per sq. in. in tension, and loadings of 19.5 tons, 25.5 tons, and 28 tons per sq. in. nominal stress were applied.

If for practical purposes 10,000,000 revs. is considered as approximating to the fatigue range of the material, it will be seen that this wrought iron might be predicted to be capable of withstanding + or − 11.7 tons per sq. in., but if the data derived are plotted, it may be determined that this stress of 11.7 would have to be lowered to between seven and eight tons for a successful life to infinity. As, however, even in our own industries parts are called upon to withstand hundreds of millions of revolutions, a value selected somewhere between 11.7 and 7/8 tons may be taken as indicative of the possibilities of the material for practical purposes. For motor-car parts a good life would be represented by 200,000,000 revs. It will therefore be seen that it is extremely difficult to say arbitrarily, even with the aid of substantial experiments, exactly what the safe range of stress may be.

Turning to automobile steels, the author said that the same steels in as near as possible the same conditions as described in last year's Paper were used for the experiments with one or two additional carbon steels. Commenting on the percentages obtained the author considered the carbon case-hardening steel results in the hardened condition as being misleading since the outer layers of the Wöhler bar would be harder than the interior, hence the Wöhler values would be expected to be somewhat disproportionately higher than the tensile values. The values of the 0.15 per cent. carbon steel he also looked upon as requiring further confirmation. The air-hardening nickel-chromium steel which gave such low values was not misleading, the Brinell value of the Wöhler piece being slightly higher than that of the tensile piece.

The other results might be taken as reliable within ordinary experimental error, and the author did not consider he was diminishing the value of this experimental evidence when he drew attention to the difficulties in the way of obtaining, in a somewhat heterogeneous material, that absolutely uniform condition necessary for accurate quantitative deductions. As regards the question what deductions might be drawn from these figures, in the first place it was felt that the relationship to the primitive limit of proportionality was erratic, and he was inclined to place little importance on the latter values. When they came to the relationship to the yield stress and to the maximum stress they seemed to be on firmer ground, although in considering even such relationships they must remember the arbitrary manner in which the yield point was determined, and the real value of the figure stated as the maximum stress. After such reservations, however, useful deductions can be drawn.

The outstanding fact which was derived so far was that the high tensile alloy steels (M.S. of 50 to 65 per sq. in.) had a materially higher fatigue range than carbon steels of the same hardness. This observation concerned the normalised condition of the carbon steels; the hardened and tempered condition of such steels had not been dealt with for the reason stated, i.e., the unsuitability of carbon steels for the hardening and tempering operations except in the thinnest sections. For 10,000,000 revs. the safe range of stress for carbon steels, as used in the motor industry, was from 12 to 18 tons per sq. in. For alloy steels the comparative figures are 21.5 to 28 tons.

SOUTH AFRICA. — TENDERS INVITED. — His Majesty's Trade Commissioner at Johannesburg has forwarded to the Department of Overseas Trade particulars of a call for tenders by the Kamanassie Irrigation Board for the supply of the following materials required in connection with the construction of irrigation work:—Contract No. 16.—Ten 36-in. sluice valves, spindles and headstocks, together with the necessary cast-iron special pipes and jointing materials: Contract No. 17.—Six tons of wrought-iron gratings, ladders, etc.: Contract No. 18.—Twenty-six wrought-iron or steel sluice gates and headstocks for canal intakes: Contract No. 19.—About 5 tons of copper plates. Specifications and further particulars may be obtained from the Engineer, Kamanassie Dam, Oudtshoorn. Tenders must be submitted to the Secretary, Kamanassie Irrigation Board, Oudtshoorn, and be received on or before April 30, 1921.

CUPOLINE.—Messrs. E. Capper, Robson & Co., Ltd., of 1, North Road, Darlington, inform us that they have been appointed sole licensees for cupoline, a Dutch material. This material is composed of quartz sand grains of various fineness enveloped in a coating of kaolin. It is placed upon the market as a competitive material to ganister, but it can also be used to replace fire-bricks in many cases.

XUM

The Co-operation of Scientific and Industrial Research in the Iron Foundry.*

By Thos. Vickers, C.E. (Secretary British Cast Iron Research Association).

To discuss such a subject in all the aspects that it presents to us would entail a considerable amount of time, therefore for our present purpose it will be sufficient to consider some brief salient points so far as we can connect them with our foundry work.

There is no subject concerning industry which is more active to-day than the relation of science to industry, and especially the development of scientilc research which may be applied to industrial ends. When so much emphasis is being laid upon the importance of scientific guidance in manufacturing operations it is becoming more generally recognised that research is an essential preliminary to industrial progress, whether the industry be ironfounding or engineering, therefore we can lay it down as one of our first maxims that no plans for the future development and efficiency of any industry can be considered to be complete unless they provide for industrial and scientific research.

Whilst this statement can be taken as a basic principle for any industry, it is especially true of the ironfounding industry, which can rightly claim to be of considerable national importance.

Science can be defined as "*exact* knowledge." The word *exact* distinguishes science from knowledge as it is understood in its ordinary sense.

Science can also be defined as the "Study of natural phenomena, and the formulation of laws based upon observation of cause and effect."

Whilst the majority of manufacturers in this country have been forced to admit the value of the help which science can render, they have not advanced beyond the stage of accepting this view in the abstract, and they are as yet far from applying it in practice, but to meet the growing foreign competition the principle already accepted grudgingly, and in the abstract, will have to receive whole-hearted appreciation of industries generally.

What is Industry?—Industry is the art of producing from one form of substance other forms of substance for which there is a demand. Under present circumstances this production in our foundries takes place in such a manner, and under such methods, that the maximum of efficiency is rarely, if ever, attained. Maximum efficiency requires that in the process of manufacture the least cost shall be incurred, and the best article commensurate with cost produced. Industrial efficiency begets prosperity, and prosperity leads to general contentment.

A Historical Sketch.

The British were the pioneers in the world's industry, and enjoyed for many years the advantage of an early start. The world was our market, and British goods went everywhere without very much commercial opposition. At one time we were the largest exporters of iron castings, which position we have now lost. The great growth of trade in America and Germany is due without any doubt to the application and co-operation of science to their industries.

The probing into the fundamental principles of a process, whereby a thorough working knowledge is attained, laid the foundation of America's great malleable cast iron industry.

A comparison of the progress made by the ironfounding industry during the last 50 years with the progress made by such industries as steel manufacture, the non-ferrous metals, the electrical, chemical, engineering or photographic industries will show that the foundry trade has not made such great use of scientific discoveries for the improvement of its methods as have the others mentioned.

The German for years has fully realised the great value of science, and to him failures have been but stepping-stones to new industries. When we read of a German firm spending three-quarters of a million on one experiment to produce indigo from a waste tar product it is only one of numerous cases where science has helped industry by working in co-operation with her. There are very few industries where chances of utilising waste have not come along, but usually the individual or the firm to whom the opportunity occurred finds he has not sufficient scientific knowledge of the subject or breadth of view to realise the importance of the occurrence.

The originators of our early industries were without doubt men of some scientific outlook, they never ceased experimenting (as far as their limited knowledge allowed them to do) to perfect their processes, but the cost of production under their crude methods was naturally very heavy. But there was absolutely nothing to prevent the utilisation then of all the conveniences now at our disposal except one thing—the lack of knowledge. Everything else was at hand as much in those early days as it is to-day, except the ability to co-operate with science.

Very few records are in existence as to the early days of cast-iron iron-founding, but still its history is full of romance and well worth any trouble to look into. No material subject is more fascinating than a study of iron, for no substance on earth has more profoundly influenced the destinies of the human race.

There is no doubt at all that the industry flourished in this country before the Roman invasion. Direct evidence has been found that at this early period the use of iron and the mode of reducing its ores were well known. A furnace was used which corresponds to what we know as the blast-bloomery, which by subsequent improvements developed about the year 1520 into the blast furnace, which was first used in this country in Sussex.

As the demand for iron, in those days, increased they increased the size and height of the bloomery, and this without doubt led to a very unexpected discovery. The greater length through which the ore had to descend would, of course, prolong its contact with the charcoal, and a higher state of carburisation would ensue, the product being cast-iron, although they did not know it then as such. But, curiously, this result was also the beginning of the early improvements in the smelting furnace. In the Forest of Dean are still to be seen the remains of two of these early period blast-bloomeries.

The first foundry in this country to be run on any commercial lines is said to have been at Buckstead (Sussex) in 1361, but iron-founding as an industry, can be fixed as beginning about 1500. The progress of the art—because it was considered an art in those days—was very slow. Sussex, without doubt, was the premier iron-founding district at this period, or what we can call "The Black Country" at that date.

In 1550 the first treatise on cast iron was published by a founder called Agricola. It is very quaint reading, in it he says:—

"Iron melted from iron-stone is easily fusible, and can be tapped off. When the same, after the slag has been lifted off, is further heated to redness it becomes malleable."

One can easily imagine this old founder by trial and error arriving at certain conclusions, without the least idea why it was so, and writing down his experiments. If he had possessed the least scientific instinct the future malleable cast-iron history might have been very different.

In studying the artistic side of the production of those early moulders one wonders at the patience and the care they exhibited in their endeavour to improve their work; one can really call it research, although probably the word was quite unknown to them. Samples of the work produced between the years 1510 and 1670 have

* A lecture recently given before the London Branch of the Institution of British Foundrymen.

never since been surpassed, or even equalled, by the present-day moulder.

The foundries were all situated in isolated places and there were no means to exchange ideas as to possible improvements, each foundryman carried out his work in accordance with his own experimental results; so isolated were they that the pig-iron had to be conveyed for miles on the backs of pack horses and the metal returned in the same way. Still we find that in their own crude way they adopted methods of improvement which in their shrewdness they knew were necessary to increase their trade, and as their methods of production improved, their skill as craftsmen enabled them to produce the splendid examples of the moulders' art which are in existence to-day.

Quantity production was of course unknown, and although loam moulds were also unknown, the art of moulding in flasks was carried out as early as 1690. Darby also took out a patent for moulding in 1709.

A very interesting series of analyses has been made of oven plates which were made about the year 1508, and is as follows:—(Average figures)—Silicon, 1.17; phosphorus, 0.40; manganese, 0.38; sulphur, 0.08; graphite, 3.0; combined carbon, 0.67; total carbon, 3.82.

Sussex still continued to be the centre of the industry in this country on account of its timber and ore supplies. At this time she had about 140 foundries and 10 large furnaces (to-day there are about 7 foundries, and, of course, there are no blast furnaces).

In 1543 the first cast-iron gun made in this country was cast at Buckstead (Sussex), and in the first year one foundry made 43 cannon of 3 tons each or 129 tons, a whole year's work, and curiously, their early guns were made by a man named Hogge, who knew nothing whatever about making guns or the preparation of the moulds, but he was an expert melter. His patient experiments and failures, however, resulted in Sussex soon becoming the centre of the cast-iron gun manufacture of the world, and they exported guns over all the Continent. The historian Hume said that "the founding of iron cannon was the only *art* in which the English then excelled." Hogge alone found out the secret of casting these large guns, and kept it. Sussex foundrymen were, however, induced to go abroad, and the Sussex gun trade in 1574 began to give way to the making of cast-iron pots, pans and the like. To retain her position some French foundrymen were brought over, and there is no doubt our industry owes a great deal to their inventions, skill, and genius. We still retain terms in the trade which owe their origin, without doubt, to these French ironfounders, such as furnace, founder, tuyere, etc.

Foundrymen 300 years ago were as jealous of each other, as in modern days, of any improvements, and had peculiar ways to stop competition, and we find Sussex placed under an edict whereby it was criminal to use wood in the county for melting purposes. It was also illegal to build any new foundries in Sussex, Surrey, or Kent, but the co-operation of what little scientific knowledge they had with their work enabled the Sussex ironfounder to fight his rivals, and the attempt to close down their foundries by prohibiting the use of wood caused investigations to be made for a new fuel, and in 1611 Sturtevant patented the use of mineral coal, but Lord Dudley, however, in 1619 overcame some of the difficulties experienced in making cast iron with coal fuel.

Cast-iron pipes were not made to any extent until 1660, and 1664 saw the laying of the first great cast-iron water pipe line at Versailles; it is interesting to note that there are still five miles of this old water pipe line in use. Then came the greatest development in the trade through the energies, practical work and ability of the Carron Bros. in Scotland, in the early part of the 18th century.

The art of pattern-making began to be highly developed, and no better example of persistent experiment, patient investigation, and the calling into aid of every then known scientific law can be recorded than the final solution by Darby and Thomas in 1710 how to overcome their many troubles experienced in moulding. The result of Thomas's experiments was carried out in one foundry only for over 100 years at Colebrook Dale, where the production of cast iron, in a mould of fine sand with its two wooden frames and its airholes, was carried out behind locked doors.

Darby eventually in 1735 successfully proved the result of his patient research by making cast iron by means of coke fuel on a sound commercial scale, and to him, as we know, is due the first successful use of coke in the blast furnace. Darby, with his limited knowledge truly found the value of scientific co-operation. But it was Réaumur, the Frenchman, who without doubt was a scientist and brought science into full co-operation with his work. He carried out the first cupola melting in Europe about 1720; it soon gained ground and a patent was taken out in this country by Wilkinson of Sheffield in 1794.

Slow as the foundries had struggled without any practical knowledge, the year 1800 saw primitive science triumph by the general adoption in this country of cupola melting, and its advent seems to have given the ironfounder an incentive to adopt more practical ideas. The cupola was not adopted in America until 1820. The present day cupola follows very close the lines of Wilkinson's cupola of 130 years ago, so little have we advanced since.

Moving rapidly on we come to 1880, when a great advance in the industry came as the direct result of the co-operation of science with the industry. The advance took place not only in Germany, France, and America, but also in this country, and curiously all at the same time. The development and improvements in our modern foundry work can safely be said to have commenced at this period, but while America and other countries further advanced by giving science full play in their work, the industry in this country practically stood still.

Turning back again to Réaumur—who first stirred up the scientific spirit in the foundry world—in 1722 he published his famous treatise on "Softening Cast Iron" by heating it packed in red ore. His principles were at once adopted in this country; indeed, we still produce malleable castings upon much the same lines as laid down by Réaumur 200 years ago, so little have we advanced. The co-operation of science with our malleable iron industry has not yet been very prominent. A hundred years ago we were the largest producers of malleable cast iron in the world—our output to-day of 66,000 tons per annum is less than our output some years ago. America's output is 1½ million tons per annum, which we shall consider later. The cause of the decline in the malleable industry is because it is chiefly in the hands of small manufacturers who have neither taken the opportunity nor have the desire to study deeply the scientific principles which underly their methods of production. And it is a remarkable fact that you can search in vain the scientific and technical literature in this or any other country for any important contribution from the British malleable cast-iron industry.

Between 1769 and 1804 several patents were taken out in this country for making malleable cast iron, and it is curious to relate that Matthew's patent of 1783 was the germ of the "Blackheart" process discarded for a long time in this country and so successfully carried out in America. But we are now seriously adopting it, and it is being made by several foundries in this country.

Adopting Réaumur's principles, the ironfounders in this country were soon in trouble; the science of metallurgy and the chemistry of analysis were little known and understood, and many difficulties were encountered, chief of which was the uncertainty and time of the annealing process and the subsequent lack of uniformity in the finished castings. To-day (200 years after) we are still discussing these very problems.

The emigration of Boyden in 1820 from Sussex to New Jersey was an event that proved of great importance to America. He without doubt was a progressive founder, and we can think of him as being anxious to increase his practical knowledge. Réaumur's invention would excite his curiosity, but he could find very little encouragement in this country and no one to assist him to any further scientific knowledge, and so we find him starting the first malleable cast-iron foundry in America, melting buckles and harness fittings, and proud to

announce that he had a "large" furnace that could melt 10 cwts. at once, but even in his new surroundings Boyden found little scientific encouragement, and he failed to solve the underlying principles involved in the production of malleable castings. He, however, kept very careful records of his experiments, which eventually formed the groundwork for other investigations when America brought science into co-operation with the industry, and so laid the foundation of the trade that eventually turned out nine-tenths of the world's production. Boyden's recorded experiments stand as a monument to his memory, and as an example of the value of co-operating science with his work. In 1828 the Franklin Institute offered a medal (the first of its kind in the world) for the best piece of annealed cast iron, and Boyden secured it by submitting 12 pieces. It should be remembered that in Boyden's time the production of a few tons of malleable castings a week required more thought and worry than producing 100 tons a week to-day. He had then succeeded in removing some of his difficulties of producing malleable cast iron and he made what were then considered to be very high grade castings. His example took effect, and patiently and persistently the scientific aspect of foundry work permeated the trade both in America and Europe; the heartrending struggles that were experienced by those who brought order out of chaos had their reward by the adoption of sound practical methods and the dissemination of ideas. The great change that then came over the industry did not affect so much the principles of the processes as the methods by which they were carried out, but it was too late in this country to recover the trade lost in malleable work. We had sent the secret of malleablising over to America because we were too slow to realise what scientific co-operation would have done to assist us to retain our premier position. We had relied so much upon trial and error for progress in the past that, costly as it was, craftsmen adhered to the tested and tried methods rather than depart into the unknown.

The archaic character of British foundries up to 1840 was simply the result of being owned by men who were opposed to any modern scientific development. Years of effort by the more unselfish men in the trade were required to overcome their inertia. Very little foundry technical literature was then being published; indeed, up to 1850 there was practically none. Since Réaumur's book upon malleable work, published in 1722, no further work upon the subject was written until comparatively recent years. There is, however, in the Berlin Museum a copy of a rare old manuscript book upon iron, dated 1454, in which is described the art of "making molten iron being run into well baked and highly heated loam moulds." Arsenic and tin were used to render the metal more fluid. This book also describes the furnace as terminating in a "Kuppel," or cupola. Here perhaps is the origin of the word "cupola."

1864 saw the issue of the first practical foundry book by Percy. In 1865 Professor Ledebur (a German metallurgist) issued his work upon foundry practice, and gave the first insight into the great value of co-operating science and the foundry. West's classical book followed in 1881. More recently works by Professor Turner, Dr. Moldenke, Dr. Hatfield, Dr. McWilliam, Dr. Longmuir, Stoughton, and other writers have appeared. But practically this short list comprises to-day the only practical literature upon cast-iron foundry work. Compare it with the vast number of technical books written upon the production and working of steel or upon non-ferrous metals. To-day, however, scientists are giving unselfishly the results of their discoveries so that all may benefit, but their work barely touches the fringe of the great problems that await solution in our foundries.

Until the end of the 19th century progress in this country continued to be slow, metallurgists were not very interested in cast-iron work, and what developments were carried out were the result of experiments conducted by rule-of-thumb and guesswork. There was plenty of ambition to work upon more exact lines, but the knowledge to do so was held by very few foundrymen; the jealousy that existed between firms, together with the closely guarded so-called secrets, hindered progress so much that towards the end of the 19th century the industry was approaching another crisis. This condition of affairs could not last for long; there was a growing demand for iron castings, especially malleable, although prices were high and the quality very poor. British foundrymen saw America forging ahead and capturing her markets, as the direct result of her complete co-operation with science. But during the past 30 years a great many prejudices have been broken down, many improvements made, special coke-irons have been introduced, improvements in plant, introduction of steel scrap, the use of the pyrometer, etc., all the result of patient research. But whatever failures were met with in those early days there are many outstanding successes, which in themselves proved that some of the old ironfounders knew a little as to the value of science. The invention of the steam engine could not have been accomplished without the ironfounder, and it must be remembered that the first iron bridge in this country (and probably in the world) was cast as far back as 1788, erected over the Severn at Ironbridge, and is still in use to-day.

Recent investigations, such as those of Turner, Stead, Hatfield, Teng, and others, have done a great deal to solve difficulties, but we are still a decade behind.

Consideration of Present Conditions.—The trade in this country is divided into two nearly clear-cut divisions, the grey iron castings and the malleable castings. There are about 3,000 foundries in the country, of which about 170 are malleable foundries.

Broadly speaking, it can be said with accuracy that the foundries in this country are farther behind to-day than in any other country in the world, which is a serious matter, both industrially and nationally.

The effect the foundry has and will continue to have on the future prosperity and development of the engineering industry is a serious proposition, yet it is a fact that engineers during the last year or two have blamed the foundry for the upsetting and delaying of their programme, and making their schemes for mass production impossible.

It may be argued that the position is one that is usual to firms producing what is not a proprietary article. However true that may be, the plain facts are that at the present time the industry seems to be on the verge of entering another trade crisis, of a nature never before experienced in its history.

As the "Times" recently pointed out, it is a remarkable fact that while all other kindred trades, engineering and steel works, are discharging labour, there is a great shortage in the foundry industry. It still seems stunted, and lacks that standard of organising intelligence that has been developed and secured in the other branches of engineering.

What are the causes for this? The reasons why youths of any superior type do not enter the foundry are not far to seek. During recent years the only essential qualification for a foundry has been muscle and not brains, a policy to which many foundries still adhere. The quantity of scrap castings made every day is the only result of such a policy. The quality of the present day worker employed does not enable him to diagnose the cause of such failures, for they are seldom capable of formulating and applying an effective remedy.

In many foundries some of the old laborious practices of our grandfathers are still in operation. Take, for instance, the mixing and preparation of sands without any mechanical assistance, the cleaning of castings, the lifting of heavy castings by manual labour, the ramming up of moulds by hand. In some foundries men are ramming from morning to night in the making of large moulds, work which could be done by mechanical power.

Are the conditions of foundries to-day such that they will attract a class of intelligent workmen? Some of them are kept in such a condition that they have a degrading effect upon the men employed, and personal cleanliness and appearance are rarely thought of.

(To be continued.)

Heat Treatment of Copper Alloys.*

By J. S. Glen Primrose, A.R.T.C.

When an alloy of copper with another metal has been properly melted and cast, it solidifies with the formation of a structure which is composed of a large number of interlocking crystals, and these may be of large or small size, and generally of varying composition, depending upon the rate of cooling of the metal. Not only this rate of cooling, but also the conditions of solidifying have a good deal to do with the original structure and, therefore, the strength and properties of the alloy, but although it is solid it does not necessarily follow that further changes are impossible. Even at normal temperatures, changes may take place in the material tending to produce stability, and with rising temperatures these changes towards equilibrium take place more readily as the degree of freedom increases. In this way important structural changes are effected which have a profound influence on the metal, and varying and useful modifications take place as the result of such heat-treatment as annealing, quenching and sometimes tempering also.

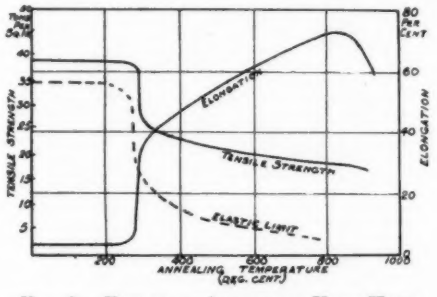


FIG. 1.—EFFECT OF ANNEALING UPON HARD DRAWN CARTRIDGE BRASS.

The Brasses.—The effect of heat treatment of different kinds upon the usual industrial brasses has been repeatedly explained and experimented upon, so that only brief reference is necessary to this most important subject. Whilst many classes of cast brasses require no heat-treatment for the purpose they are designed to serve, the large amount of cold-worked brass requires this treatment to be very carefully conducted, as without it failures would be of too frequent occurrence. Taking as a typical example the case of a cold-worked cartridge brass, it is found that when the amount of reduction imparted to it reaches about 40 per cent. the ductility is almost completely destroyed, due to the breaking down of the crystal structure caused by the working. When the thickness has been reduced to about one-half (to give 100 per cent. cold-working value), the strength and hardness have been much increased, still at the expense of the ductility, and if more drastic reduction is made without resorting to annealing the material may easily be ruptured.

An interesting graph (Fig. 1) shows the general result of the variation of the temperature of annealing a hard-rolled cartridge brass of 67 : 33 composition, which corresponds with other cold-working brasses of different compositions. The diagram shows the existence of five separate zones of practical importance, which can be closely correlated by physical testing and microscopical examination. In the first zone from normal temperature up to about 250 deg. C. the effect of the heating is nil, leaving the high tensile strength and low elongation unaffected, the crystals being broken and in the completely cold-worked condition. The second, "relaxed" zone, lies between 250 and 350 deg. C., where the physical properties change in a very sudden manner, and groups of small, closely packed crystals appear. In the third, "recuperation" zone, the size of the crystal grains gradually increase, and the tensile properties modify comparatively slowly as the temperature rises from 350 to 750 deg. C. Then in the fourth zone of "complete annealing," from 750 to 850 deg. C., the crystals have attained their maximum size and the properties of the alloy are not appreciably different whatever the temperature of annealing within this range. Finally, there is the "bending" zone, between 850 deg. C. and the fusion point, in which both the elongation and tensile strength diminish and the elastic limit falls almost to zero, gas cavities appear in the structure which often resembles the alloy as originally cast after this too drastic annealing, which is practically akin to burning.

Heat Treatment of the Bronzes.—The earliest records of work in this direction date from 1897, when Roberts-Austen, with Stansfield, as well as Heycock & Neville, published their researches into the constitution of the pure bronzes. To determine the limits of some of the transition products, small pieces of different alloys were annealed and quenched at various temperatures, and the structures examined microscopically. In this way very great differences were observed, but no practical use was made of these discoveries.

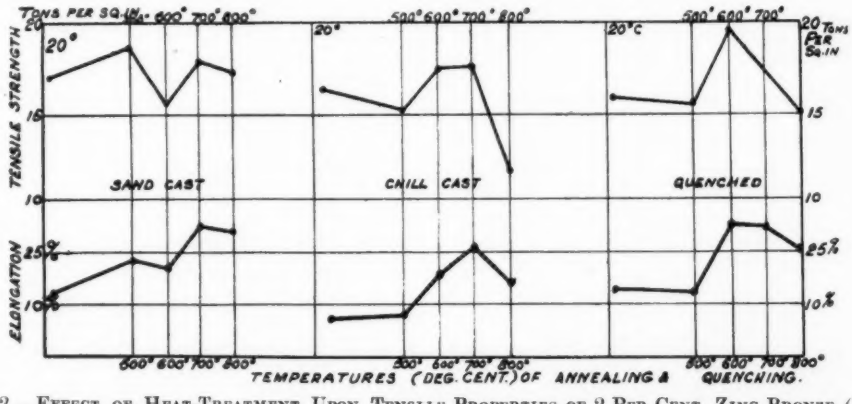


FIG. 2.—EFFECT OF HEAT-TREATMENT UPON TENSILE PROPERTIES OF 2 PER CENT. ZINC BRONZE (NAVY GUN-METAL).

It was not until after renewed work had been published in 1901 by Shepherd & Blough and some former contradictions in the previous work had been cleared away that the practical importance of this purely theoretical work began to be apparent. This led Guillet to perform a large number of full-sized test-bar experiments, taking quite a wide range of composition, the tin content varying from 5 to 21 per cent., and the quenching temperature rising from 300 deg. to 800 deg. C. He arrived at the conclusion that in the case of bronze alloys containing over 92 per cent. of copper the tenacity and the elongation are slightly increased by quenching from between 400 deg. and 600 deg. C., whilst in the case of alloys containing less than 92 per cent. copper, the tenacity and elongation increase decidedly as

* A lecture recently given before the London Branch of the Institution of British Foundrymen.

soon as the quenching temperature exceeds 500 deg. He got maximum tenacity in each series by quenching from 600 deg., but the greatest elongation was obtained with high copper content at about 800 deg. C., whereas with the lower copper content only 600 deg. was needed. The greatest difference between the normal cast alloy and that of the quenched alloy was greatest with the lesser percentages of copper, both for tenacity and elongation, from which it appeared that quenching the pure bronzes caused a decided improvement in the results of tensile tests.

It is to be regretted that no data were recorded as to the methods of conducting this important research, since it has a most important bearing upon the results obtained, whether the metal tested was cast in sand or in a chill, whether cast separately, or cut from a sufficiently large casting to represent commercial practice. It is not stated either whether the quenching of the test-bars was effected as they cooled down from casting temperature, or whether they were allowed to cool down then receive reheating treatment, and, if so, for what time the various temperatures were maintained before the quenching was done.

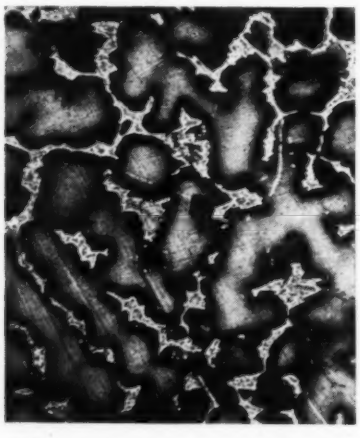


Fig. 3.—Slowly Cooled Gun-Metal.

Fig. 4.—Annealed Gun-Metal After Stressing.

Gun-Metal Bronze. — After pointing out in a paper to the Institute of Metals, in 1910, the extreme importance of controlling not only the limit of tin in the chemical composition, but also the temperature of pouring, for variously-sized castings of gun-metal bronze, Mr. H. S. Primrose suggested that some form of heat-treatment, either by quenching or annealing, would effect similar remarkable results to those experienced in the pure bronzes detailed by Guillet. After several years of research work on this subject, carried out in a large works in collaboration with the author, further details of the effect of heat-treatment were published and have since been more fully elaborated.

The first surprise found in taking normally cast gun-metal bars, which had been cooled off like the castings in dry-sand moulds, was that quenching did not have the same beneficial results with the two per cent. zinc bronze that it had on the pure bronzes of Guillet.

The figures given in Table I. for the tensile strength and elongation of the original set of quenched test-bars showed that the physical properties of the heat-treated metal were much poorer than the normal sand-cast material, as the strength and elongation fell off consistently as the quenching temperature rose to 700 deg. C., after which a slight improvement was noted. This set of changes was readily explained by the microstructures of the alloys, which showed how the delta constituent first of all dissolved, and then finally disappeared, leaving only at 700 deg. a coarse structure of alpha and beta constituents which was defective in strength and ductility.

Table I.—*Effect of Heat Treatment on the Physical Properties of Admiralty Gun Metal.*

Temp. of annealing for 30 min.	Sand cast.—Slowly cooled. T.S. tons per sq. in.	Elongn. per cent. on 2 in.	Brinell hard-ness.	Chill cast.—Quickly cooled. T.S. tons per sq. in.	Elongn. per cent. on 2 in.	Brinell hard-ness.	Chill cast.—Slowly cooled. T.S. tons per sq. in.	Elongn. per cent. on 2 in.	Brinell hard-ness.
Normal	77.2	24.0	63	15.0	4.0	86	18.6	20.0	72
500 deg. C.	15.1	26.5	65	12.3	7.5	80	16.7	9.0	78
600 deg. C.	16.3	28.5	61	19.6	25.0	75	15.0	17.0	71
700 deg. C.	18.0	37.5	60	20.0	30.0	74	22.5	45.0	66
800 deg. C.	15.5	31.0	60	17.2	22.5	70	18.6	34.0	68

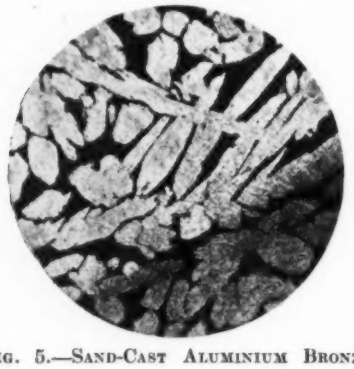


Fig. 5.—Sand-Cast Aluminium Bronze.

It is remarkable that several experimenters have repeated the above set of quenching experiments and got various results. Those tests conducted under conditions approximating closely to works practice have agreed with the original findings, but those conducted under small scale laboratory experiments have differed. Thus Comstock, of America, and others in this country, have found the deleterious effect of quenching gun-metal, but, on the other hand, the American Bureau of Standards have found almost the reverse effect when they took the average results of four test-bars quenched at different temperatures.

Their object was not, however, to find out the best treatment to give strong, ductile and hydraulically sound castings for commercial work, but simply to determine the best way to get high testing values out of separately-cast test-bars. These were usually cast to size and not machined, which of course makes a very great difference when compared with larger cast-on test-bars which have subsequently to be machined down to less than one-third the former cross sectional area. Then, again, it was not clearly stated if the test-bars

so prepared were quenched from casting temperature or re-heated from cold after casting. Further, if the time (during which the bars were kept at the temperature from quenching occurred) was unduly prolonged, then it is no doubt true that if they had accomplished a complete annealing of the metals to make it perfectly homogeneous, naturally the rate of cooling down to normal temperature again could be either rapid or slow without affecting the resulting properties of the alloy.

Reference to the graphs shown in Fig. 2 will also show that there must be some other disturbing factor than the quenching effect to give, for example, so wide a variation between two test-bars, each quenched from 700 deg. C., as from 15 to 25 tons per sq. in. tensile strength.

FIG. 6.—10 PER CENT. ALUMINIUM BRONZE, SELF ANNEALED.

Simple Annealing.—Having shown that water quenching of gun-metal castings spoils it, as Comstock says, through the material developing numerous cracks all over when it is stressed, the next step was to try the effect of simple annealing treatment by heating the metal up to various temperatures, keeping it there for different lengths of time, and then cooling off moderately slowly. Whilst it had been shown that the strength and ductility of the metal had been very strongly affected by the primary rate of solidification, as well as of subsequent cooling, all the series of tests carried out with numerous test-bars showed the completely beneficial effect of annealing at the right temperature for the correct length of time.

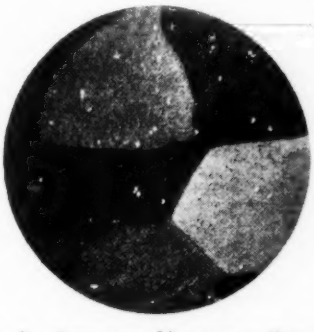


FIG. 8.—QUENCHED MANGANESE BRONZE.

The net result of all the figures obtained, shown in Fig. 10 as well as in tabular form, was to the end that 700 deg. C. was the most useful in commercial practice, and that one hour for each square inch of section gave the most marked improvement. The improvement looked for was not merely in regard to test-bar results, but in the general improvement in castings which had not only to be strong and ductile, but also be capable of resisting very high internal water-pressures without showing the slightest leakage of water. Naturally for such material as bearings, etc., another set of conditions arises, but even for that purpose it may be that reduced wear can be attained, as well as fuller freedom from corrosion, as the results of a suitable annealing of gun-metal castings.

The general effect of this simple annealing is to eliminate completely the very gross differences which occur in the structure of a normally cast and slowly cooled gun-metal casting. As illustrated by numerous slides of photo-micrographs (Figs. 3 and 4), it was seen that the trouble arose through the separation of a hard, brittle eutectoid which is often unable to fill-up completely the interspaces in the primary alpha crystallites of copper-rich metal which freezes out of the liquid mass first of all. The eutectoid is a complex of very highly concentrated tin-copper compound along with some secondary alpha constituent, and the failures in strength, etc., are usually traceable to the wrongly arranged disposition of this eutectoid.

FIG. 7.—MANGANESE BRONZE AS CAST.

Even when it is correctly arranged, in the smallest possible distribution through the copper-rich mass, without any intercommunication across the interlocked mesh-work of primary crystallites, it is found that the annealing completely eliminates this harmful constituent by causing it to gradually dissolve, without melting, of course, in the remaining alpha constituent, thus giving a resulting homogeneous structure of very much improved properties and quite water-tight.

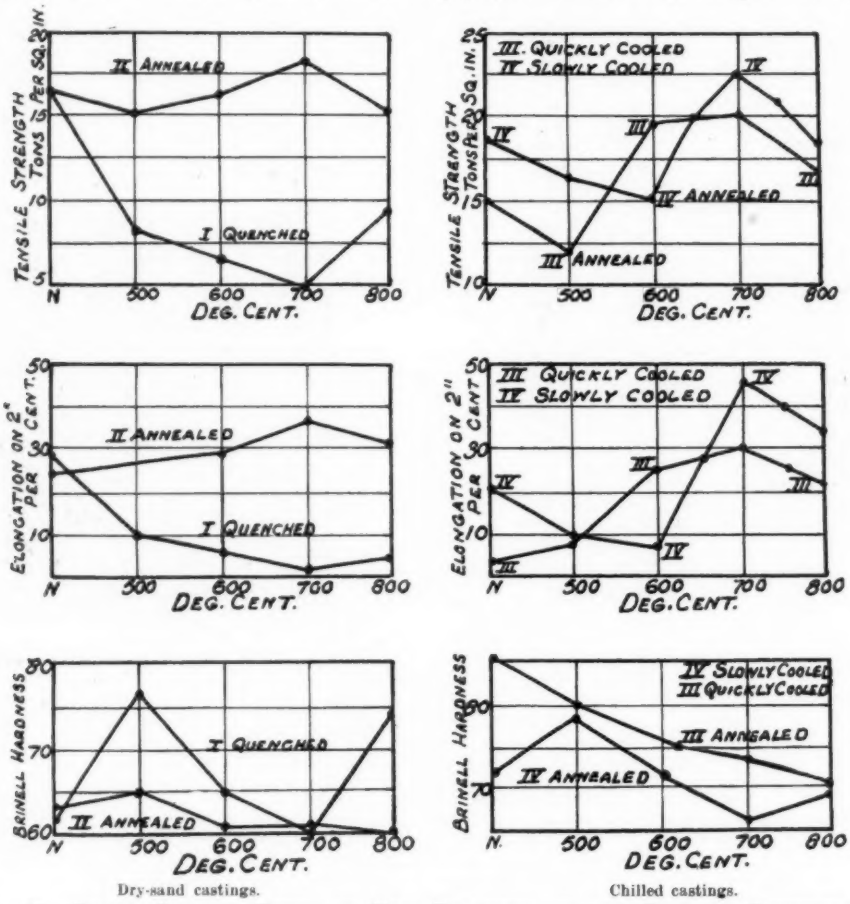
It is interesting to note that most practical experimenters who have tested this annealing treatment on the commercial scale have confirmed the author's results, Comstock in particular getting confirmatory results, which are shown in

FIG. 9.—QUICKLY COOLED MANGANESE BRONZE.

Table II, even although the improvement he records is less marked than that first recorded in 1913. No doubt that is accounted for by the fact that his normal cast bar was cast to a small size ($\frac{1}{2}$ in. diameter), and not machined before being tested on a 2 inch gauge-length, whereas the first tests were made on an inch round bar as cast, but turned down to $\frac{5}{8}$ in. diameter for the test-bar.

Other experimenters have not recorded quite so close agreement in their work, as, for instance, Longbottom and Campion, who asserted that they could remove the eutectoid areas by a short annealing at 250 deg. C., but that annealing at higher temperatures restored the weaker cored-structure. Their tests did not go above an

annealing temperature of 600 deg. C.; although their curve showed an upward tendency then, they had not continued to the full 700 deg. C. which is considered necessary by the author. They claimed that castings would be burned or deformed by such high-temperature annealing as that recommended, at 700 deg. C., but no such ill-effect has ever been observed in works practice, where results are not recorded in tables, but graphically only (Fig. 2), with points to indicate the actual values from which the average has been taken to give the graph line. It is perhaps a remarkable coincidence that if the results of the test-bars quenched at 600 deg. C. and those annealed at the same temperature were transposed in the American paper, then almost complete agreement with our



Dry-sand castings. Chilled castings.

Fig. 10.—Graphs Showing Effect of Heat Treatment on the Physical Properties of Gun-Metal.

ordinary care is taken either to let the casting remain to cool off in the furnace, or be withdrawn on a removable tray to save any handling of the casting with tongs. It was inconceivable that there could be any structural change brought about by annealing at 250 deg. C., which was admittedly below any known critical point in the zinc-bronze, and undoubtedly the primary composition as well as the unknown casting temperature had much to do with the anomalous results obtained, although they have been rather erroneously attributed to the heat-treatment afterwards.

Less easily understood is the discrepancy which has occurred between the author's results and those of the American Bureau of Standards, as contained in their Fig. No. 9 of the paper issued in March, 1916. They remark that "with annealed bars the results agree very well with those obtained by Primrose, but the results obtained from the quenched bars are not concordant." The American graph was plotted from the results of only one test-bar annealed to each different temperature.

One very striking instance which had been brought to the author's notice by private correspondence some little time ago, gave remarkable testimony to the wonderful stabilising effect which annealing produced on Admiralty gun-metal. The casting in question had to undergo very drastic usage, since after heating for long periods at 300 deg. C., it was quenched in water at

Table II.—*Effect of Heat Treatment Upon the Physical Tests of Admiralty Gun-Metal.*

Cooled from deg. C.	Cooled in.	Area.* Sq. in.	Elastic limit. Tons per sq. in.	Tensile strength. Tons per sq. in.	Elongn. on 2 in. Per cent.	Redn. of area. Per cent.	Brinell hardness No.
Liquid)	Sand ..	0.2	9.87	19.33	26.5	23.7	67
700	Water ..	0.2	8.14	8.36	7.5	6.7	66
700	Air ..	0.2	9.66	19.87	41.5	33.5	67
600	Furnace ..	0.2	9.75	21.62	50.5	46.2	71
700	Furnace ..	0.2	9.25	20.28	41.5	34.3	68
800	Furnace ..	0.2	9.4	21.49	58.0	38.0	67

* Test bars were cast to size and not machined.

200 deg. C., and the action repeated very often. Ordinary cast gun-metal was found to be unable to stand up to such heat-treatment, by developing large crystals and also harmful cracks. Tests made on bars which were subjected to the treatment the casting got in practice were able to show the great loss of strength and ductility suffered by the cast material, but after similar bars had been annealed for half an hour at 700 deg. C, they were able to resist extremely well the drastic action of repeated quenchings from 300 deg. C. Table III. was compiled from the tests communicated by Mr. H. Whitaker, and go to show a perfect confirmation of the good effect of annealing for certain purposes. All the tests were made with bars of gunmetal cast in sand and cooled down normally as in series No. I. No. II. received the quenching from 300 deg. C. in water

TABLE III.—*Stabilising Effect of Annealing upon Physical Tests of Admiralty Gun-Metal.*

Average of	Series No.	Cast in.	Area. Sq. in.	Elastic limit. Tons per sq. in.	Tensile strength. Tons per sq. in.	Elongn. on 2 in. Per cent.	Remarks.
3 bars ..	I.	Sand ..	0.25	9.5	16.2	15.3	Cooled normally.
,, ..	II.	,, ..	0.25	7.5	7.5	0.0	Cooled normally and quenched from 300 deg. C. Annealed at 700 deg. C., water quenched from 300 deg. C. Fifty times.
,, ..	III.	,, ..	0.25	8.5	14.9	26	
,, ..	IV.	,, ..	0.25	8.6	12.1	12.3	Annealed at 700 deg. C., water quenched from 700 deg. C.
,, ..	V.	,, ..	0.25	8.6	18.5	36.8	Annealed at 700 deg. C., cooled in air.
,, ..	VI.	,, ..	0.25	8.7	18.8	42.8	Annealed at 700 deg. C., cooled in furnace

Annealing time :—30 min. at 700 deg. C. ; 15 min. at 300 deg. C. Quenching water at 20 deg. C.

for 50 times before being tested, and gave very poor results. Series IV. showed the similar harmful effect of water-quenching from 700 deg. C., but No. III. shows the marked improvement of annealing at 700 deg. C. before being repeatedly quenched. Series V. and VI. further confirms the improvements got by annealing following by slow-cooling either in air or in the furnace before being tested.

It is not customary to anneal phosphor-bronze castings, particularly for bearing where the hard eutectoid is considered beneficial, but Comstock has shown that even with 11 per cent. of tin and 0.5 per cent. of phosphorus it is possible by annealing at 700 deg. C. to remove completely the eutectoid structure of delta material. When the eutectoid has been thus removed with corresponding improvement of the strength and ductility, the bearing qualities of the alloy may be expected to suffer, although experimental work by Portevin and Nusbaumer proved that least wear occurred when a cold-worked skin of alpha constituent only had been formed on a bearing which otherwise exhibited a rate of wear proportional to the amount of delta separated. The exception to this was got by quenching to remove delta also.

Aluminium Bronze.—This alloy, as commonly used, has a range of composition with 8.5 to 11 per cent. of aluminium, and shows remarkable results when it is subjected to varying heat treatments. Thus, with about 10 per cent. of aluminium it can by quenching in water from 850 deg. C. be hardened similarly to steel, and, moreover, by subsequent short-time annealing at comparatively low temperatures it can be tempered to restore its ductility, temporarily lost when the strength is so much augmented by the quenching process. The structure of the alloy is made up of primary alpha-crystallites with dark etching interspaces of so-called beta-constituent, when sand-cast and normally cooled, but after water-quenching the structure is almost homogeneous except for a needle-like structure which is practically all beta, since the alpha-crystals have been absorbed at the temperature of heating and prevented from reforming during the rapid-cooling in water. If either the quenching temperature of this alloy be too low, or the rate of cooling from the correct quenching temperature is too slow, the hardening effect is minimised, if not lost, due to the beta-structure breaking down with the formation of some of the formerly distinct alpha-crystals.

In order to remove the low amount of elongation which a tensile test-piece can undergo by quenching treatment, it is useful to temper the alloy, which not only raises the ductility, as noted by the percentage elongation and reduction of area, but also has the effect of increasing the elastic limit at the lower temperatures of annealing. The results of such thermal treatment are well shown in Table IV. from Mr. Comstock's research, which was conducted on cast-to-size test-bars, and the time of annealing at the several temperating temperatures after water-quenching from 850 deg. C. was between 15 and 30 minutes. The cooling after tempering was usually slow, it being found that cooling-off in the furnace gave better results than cooling in the air. The precaution is necessary that too prolonged annealing of the quenched alloy, say in a casting, or, indeed, any annealing at all of the unquenched alloy, is highly detrimental both to the ductility and the strength of the metal, owing to the manner in which the alpha-crystals increase in size, and the so-called beta-constituent resolves into its more stable form of a eutectoid of alpha and delta constituents. This makes a laminated structure like pearlite in steel, and induces a dangerous brittleness in the material.

TABLE IV.—*Physical Tests of 10 per Cent. Aluminium Bronze.*

Treatment.	Elastic limit. Tons per sq. in.	Tensile strength. Tons per sq. in.	Elongn. on 2 in. Per cent.	Redn. of area. Per cent.	Brinell hardness No.
As cast	8 85	33.0	19.5	23.7	100
Cooled from 850 deg. C., and quenched in water	17.5	43.4	1.0	0.0	240
Water quenched and tempered at 500 deg. C., in furnace ..	25.3	43.0	55.0	9.1	158
,, ,, ,, 575 ,, ,, ..	20.60	42.0	8.0	11.2	143
,, ,, ,, 610 ,, ,, ..	19.35	43.1	10.5	12.6	140
,, ,, ,, 650 ,, ,, ..	17.55	40.6	14.0	18.5	143
,, ,, ,, 700 ,, ,, ..	10.45	35.8	23.0	21.7	104
Large castings, untreated	8.00	25.4	12.5	15.0	—
,, ,, ,, ...	10.00	24.6	9.0	11.2	109
,, ,, double treated	17.70	34.9	9.5	15.0	—

The name given to this defective strength in large castings of aluminium-bronze is loss of tenacity due to "self-annealing." Small castings may be quite satisfactorily produced (Fig. 5), but the slow cooling of the larger ones makes them come below normal strength. The structure is very coarse-grained under the microscope (Fig. 6), with large alpha crystals and the so-called beta completely decomposed into coarse plates of alternate alpha and delta constituents in a brittle state. According to Mr. A. B. Wilson the only way to discover the presence of this objectionable self-annealing is by a microscopical examination conducted upon small

lugs cast on and then afterwards cut off and examined.

The prevention of this self-annealing requires great care. First the composition of the alloy must be controlled so as to eliminate or to modify the constituents necessary for self-annealing or else where possible rapid cooling may be used. The quenching of large castings is not practicable, both on account of the difficulty of handling them, but also because of the severe internal stresses liable to be set up in the casting. Therefore, the casting temperature should be controlled and kept as low as conveniently possible. Shaking the mould immediately the casting had solidified is said to assist in preventing self-annealing, and more often the cooling of a casting with fine sprays of water has been successful.

When self-annealing has occurred in a large casting, the metal cannot be completely restored to the full strength of normal cast metal correctly cooled. Some improvement, however, may be effected over the extreme brittleness in either of two ways:—First it may be heated till the casting is throughout above the critical point (say 900 deg. C.) and then immediately air-cooled. This restores the lamellar or plate-form of eutectoid-structure to the beta state, leaving the coarse-grained alpha-crystals almost unaffected, so that although the tensile strength is improved, the ductility is not. Second, by means of a double heat-treatment which effects a greater improvement. It consists of a short annealing at 900 deg. C. followed by water-quenching, and then a reheating to 650 deg. C., from which temperature the casting is cooled-off in the furnace. This not only improves the ultimate tensile strength and elongation, but also the elastic limit is considerably raised. The microstructure now shows a very fine grained alpha-plus-beta-structure which is strong and ductile, since the comparatively low temperature annealing for a short time has prevented the crystal-grains from coalescing into large crystals by the stiffness of the metal.

Manganese-Bronze.—Although this alloy is not a true bronze, being in reality an iron-brass in most cases, it is susceptible to the effects of heat-treatment in a manner somewhat similar to the bronzes. Thus the effect of water-quenching this alloy from 800 deg. C. is to fill it with invisible cracks which ruin the tensile properties of the metal just like the zinc-bronzes before described. It is not altogether due to the change of microstructure that this lowering of strength is due, since if a casting is made with slightly too much zinc, it causes the disappearance of the alpha-crystals, and the whole structure becomes composed of beta as is the case on quenching a normal alpha-plus-beta alloy. More likely it is the sudden contraction of the red-hot metal in the water which sets up internal strains which take it in places above the maximum stress the metal will withstand at the high temperature, and thus rupture takes place with the formation of numerous cracks.

Whilst there is no eutectoid in manganese-bronze as in the true bronzes, its duplex structure of alpha- and beta-constituents (Fig. 7) can be modified by suitable heat-treatment, with corresponding changes in the physical properties since the two structures are different in strength and ductility. The results of some tests made by Comstock illustrate this point, and the results are given in Table 5 and in Figs. 8 and 9. He concludes that if a casting is low in elongation it might be improved by annealing, and if too low in elastic limit or tensile strength but high in elongation, annealing followed by rapid cooling would be beneficial. Thus manganese-bronze castings should cool slowly in their moulds if high elongation is wanted, but they may be shaken out if stiffness is desired rather than ductility. The effect of annealing manganese-bronze, however, is slight compared with the effect of variation in the percentage of zinc, which is usually difficult to control on account of variable volatilisation loss of zinc in melting and pouring.

Table V.—*Physical Tests of Manganese-Bronze*

Heat treatment.	Elastic limit. Tons per sq. in.	Tensile strength. Tons per sq. in.	Elongn. on 2 in. Per cent.	Redn. of area Per cent.
As cast	11.8	29.5	40.0	43.6
Cooled from 800 deg. C., in water	17.2	28.7	4.0	7.5
As cast	14.5	34.6	21.0	21.2
Cooled from 580 deg. C., in furnace	12.75	33.6	23.0	21.9
As cast	12.85	35.4	23.0	23.0
Cooled from 790 deg. C., in furnace	12.7	34.7	28.5	25.5
As cast	12.75	31.7	33.0	28.0
Cooled from 820 deg. C., in air	14.3	34.5	31.0	28.2

X-Rays and their Industrial Applications.

A series of three Cantor Lectures has been delivered at the Royal Society of Arts by Major G. W. C. Kaye, of the National Physical Laboratory. The first was delivered on March 7, and the second on March 14, whilst the third, dealing with the practical application of X-Rays to industrial work, was given on March 21. We append the following extract:—

The present practical application of X-rays to the investigation of materials had reached a point where it was possible to X-ray lead to a thickness of 4 or 5 mm., tin to the extent of 12 mm., carbon steel or iron to the extent of 7.5 cm., aluminium and its alloys 12 to 15 cm., and wood 20 to 40 cm. The limiting factor was the length of exposure and voltage, and it was possible now, for example, to get a photograph through an inch of steel, using 130,000 volts, with a few milliamperes through the Coolidge tube, which took rather less than a minute. Different densities in the materials displayed different densities in the radiographs. For example, a rivet would show darker than the material in which it was placed, whilst carbon, nickel, and tungsten steels differed very little in transparency. This property of difference in densities had been made use of by storekeepers. One promising outlet for the X-ray method of testing was in regard to welding. Electric and oxy-acetylene welding had come into great prominence during the war, and an indifferent welder could turn out large numbers of welds which proved to be quite unreliable. There was no adequate mechanical test for the weld, and in any case, such a test, whether mechanical or microscopical, destroyed the weld, good or bad. When an X-ray photograph was taken of a weld, the presence of a shallow line indicated that the two parts were not truly joined together throughout the whole of the depth. Blisters and blowholes showed up as light spots, and were the sign in many cases of overheating. The examination by X-ray photography of welds up to 1 in. in thickness was now quick, easy, and certain, and with modern equipment, lengths up to 2 ft. or more could be investigated at once, the exposures taking a fraction of a second.

X-ray investigation promised to be exceedingly useful for the detection of hidden cracks in metals. Such cracks were often the sequel to pipes or blowholes in the original ingot. In the case of alloys, the uneven distribution of the component parts resulted in a streaky or patchy negative. X-ray examination would also often diagnose defective soldering or brazing; the substitution of one metal by another; hidden corrosion in gas cylinders, ferro-concrete and the armouring of cables, and in scrutinising steel turbine blades for segregations. Other industrial applications were in the manufacture of carbon and graphite brushes for electrical machinery, insulators, etc.

Publications Received.

The Bute Works Supply Company, Limited, Cymric Buildings, Cardiff. "Stock Bulletin of Current Special Offers."

London Joint City and Midland Bank, Limited. "A Great Bank."

Guaranty Trust Company of New York. "Investment Suggestions" for March.

Consett Iron Company, Limited. Revised Tables of Extras on Steel Plate and Sectional Material.

Constructional Engineering Company, Limited, Titan Works, Charles Henry Street, Birmingham. Foundry Plant Efficiency.

Some Experiences of Cupola Practice.*

The subject taken for this Paper should appeal to all foundrymen. It is proposed to give some results on a type of cupola which is in daily use for melting iron for light and medium textile castings. A number of these castings have to be fairly soft, so that they can be machined expeditiously. These castings are not called upon to have any special analysis, but to get a fairly uniform mixing from the approximate analysis of pig-iron as supplied by the makers is desirable.

The Larger Cupola.—This is the only cupola the author has seen of this type, although there may be many more in the country.

The dimensions are: Height from bottom to charging door, 15 ft.; diameter below tuyeres to melting point, 3 ft.; melting point to charging door, 3 ft. 6 in. There are four tuyeres 4½ in.

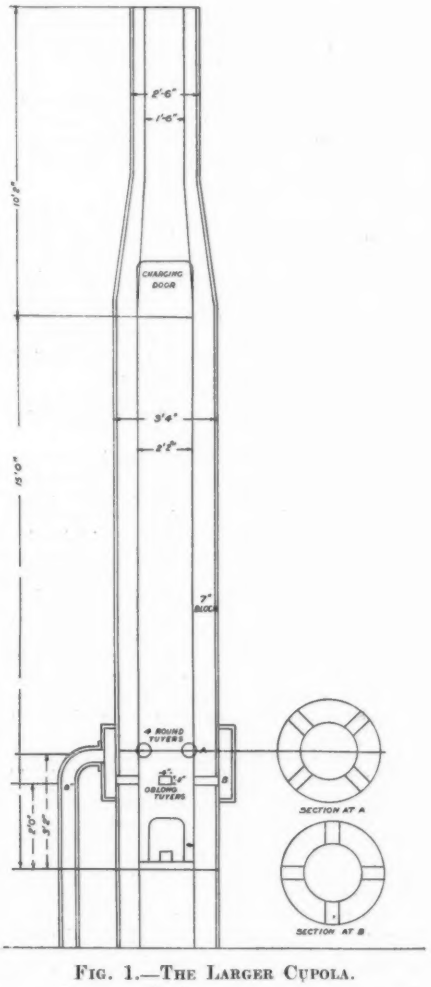


FIG. 1.—THE LARGER CUPOLA.

dia., which are arranged as shown in Fig. 1. First tuyere from the bottom, 15 in.; 2nd, 18 in.; 3rd, 21 in.; 4th, 24 in.; ratio of diameter to height, 5 to 1.

This cupola melts on an average between 50 to 60 tons per week. The author has watched this cupola carefully, and has obtained fairly good results, particularly in getting hot metal from the commencement of the blow to the finish, but he is not satisfied with its melting capacity per hour.

After ascertaining that the cupola is properly repaired with ganister wherever necessary, scones being used if the lining is much worn, the chief difficulty experienced in building and repairing is obtaining good reliable material—material that will stand the heat required to bring down the molten iron at a high temperature.

With this particular cupola some trouble has been experienced with bad material. The last time the lining was rebuilt an experienced man had all the bricks, etc., required for the job laid out for him, so as to cause no delay, and to enable him to finish the job as soon as possible. He had not been on the job more than an hour before he insisted that the bricks were useless, as they showed unbaked centres. As work had to re-commence in three days' time, and a fresh supply could not be obtained in time, a rather awkward predicament arose, thus leaving no other alternative but to use the bricks.

The morning following the finishing and drying of the lining, the bricks, to the limit of the fire, had run like slag and had congealed with the ashes at the bottom. Some of the slag had run out of the cupola. The bottom was cleaned out and another fire put in to be certain that the brick-work was dry. This resulted in the further destruction of the brick-work.

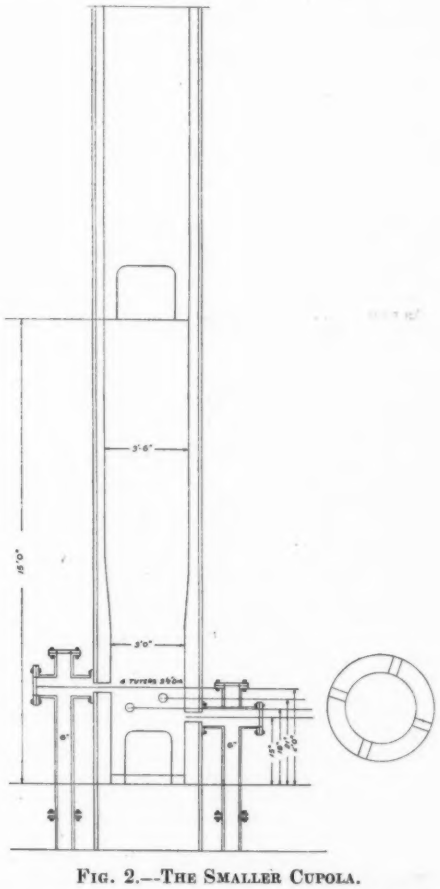


FIG. 2.—THE SMALLER CUPOLA.

Further proof of the unsuitability of the fire-bricks was obtained after the first day's blow, when on examination it was found that 3 in. of the lining had been fused away. Obviously, an enormous amount of ganister and scones has had to be used to keep the cupola in working order.

The difficulty just mentioned is a matter that should have the manufacturers' attention, with a view of obviating such serious disasters. Naturally, they on their part have their problems to overcome, but if the foundry foreman produces bad casting it has to be replaced, and the same course should be taken by firms supplying foundry requisites.

It is possible that the high blast pressure might be responsible for the quick wear of the lining of this cupola, *i.e.*, the volume of air driven in is probably in excess of what should be required for a cupola of these dimensions. A number 4 Roots blower is used, the speed of which is 380 revs. per min. On reference to the table supplied by the makers of these blowers, which gives

* Lecture read before the Lancashire Branch of the Institution of British Foundrymen.

the speed at 350 revs. per min., delivering 4,550 cu. ft. of air per minute, a blower running at 380 revs. should give nearly 4,900 cu. ft. of air per minute.

The approximate melting capacity running at 350 revs. per minute is given at 7 tons per hour. Taking this to be correct, it should be increased when running at 380 revs. per min. The melting capacity is calculated at 30,000 to 40,000 cu. ft. per ton per hour. The melting capacity taken at 40,000 works out at about 7 tons per hour, but with the blower running at 380 revs. per min. the output should be exactly 7 tons 7 cwt. per hour. In practice a little less than 5 tons per hour is being melted.

The question therefore arises, "What is wrong?" Is the diameter of the cupola too small; is the volume of air too great; or is the position and the diameter of the tuyeres responsible for the rapid wear of lining and the inability to melt the theoretical production?

In the table of particulars the sizes given for the diameter of cupola suitable for this size of blower is 36 to 48 in. Now 12 in. difference in the diameter of a cupola appears to be a large margin, although probably the diameter is too small. It would be dangerous to increase the diameter except by a few inches at a time. It is the intention of the author when the cupola is re-built to increase the diameter 3 in., as it is essential to keep the cupola approximately the diameter that it obtained after the first blow, that is, 39 in., which would constitute a fair initial trial. With good material it should increase the life of the cupola lining.

Tuyeres.—With reference to Fig. 1, it will be noticed the tuyeres are arranged or divided equally around the circumference of the cupola. A better centralisation of the blast would be obtained if all were arranged to the one height, as at present. The bottom tuyere, 15 in. from the bottom, is blowing straight across the bed, as are the three higher tuyeres, and all having little or no resistance to the other, with the high blast-pressure, and the large volume of air passing through them, carry a lot of the heat to the opposite side of the cupola, and this is largely responsible for the rapid wear of the lining.

When using the small cupola shown in Fig. 2 the blast is not varied, and the lining does not wear excessively, and needs little repair. That gives the reason for asserting that with the four tuyeres arranged in the large cupola similarly to the smaller one, *i.e.*, in direct line with each other, a better and more uniform distribution of air would be obtained. Although the blast has to pass through a mass of coke, through tuyeres thus arranged, they will have a greater tendency to penetrate to the other side of the cupola than they would if arranged opposite to each other. It should be noted, however, that although the blower is running at the same speed when operating the small cupola, the delivery conditions are totally different. The delivery pipe is connected to the air belt, so as to cause a circular current of air—this has the effect of giving a softer blast than would occur if driven direct into the tuyeres.

Tap-Hole.—The making of a tap-hole should have much consideration, for if put in carelessly accidents will occur. The method advocated is, when the fire has burned up sufficiently, to clear away the sand a little below the bottom of the cupola, to put in ganister to the height required, to place a round bar on this about 1 to 1½ in. diameter and to make up the front by ramming-up with a red-sand mixed with clay-wash, after first putting a layer of ganister against the coke and around the bar. When this is dry a good tap-hole is formed, and the chance of a mishap small. A tap-hole larger in diameter on the inside of the cupola is preferable, and this can be accomplished by using a smaller bar when the larger one is withdrawn to press the hole larger on the inside whilst the ganister is still soft. This can be better done in a drop-bottom cupola, as the tap-hole can be made before the fire is put in, and can be done from the inside. The reason for preferring a taper hole is, as most foundrymen are aware, a plugged or iron hole is due either to dull metal or to the hole not being thoroughly dry. When this happens the plug cannot be removed; if the hole is parallel, consequently a fresh hole has to be made over the top or by the side of the plug, to enable the metal to flow, and when the metal commences to flow invariably the plug gets melted away. When this happens, a ball of clay three or four times greater than normal is required to stop up the hole, and if a large quantity of metal has to be dealt with the hole will give trouble during the rest of the blow.

With a taper hole the risk is far less, and if an "iron" hole is formed the plug can be knocked inside the furnace without seriously disturbing or damaging the hole.

Charging the Cupola.—Careful charging of this cupola has always been insisted upon, and to ensure the coke-bed being the correct weight a chain gauge, with a small weight on the bottom and a bolt secured to a link in the chain, has been used. The distance from the charging door to the coke-bed charge in this case is 2 ft. 5 in. above the top tuyere. For this cupola 50 per cent. pig-iron and 50 per cent. scrap is used. This has to be thoroughly mixed, as three or four different brands of pig-iron are used, and the crucible or well of the cupola will not hold a large quantity of metal, at the most 12 to 14 cwts.

The method followed is, whilst one man is putting on the various brands of pig-iron the other is charging in the scrap until the whole charge is made. By this method a fairly uniform mixing of pig-iron and scrap is obtained, and during the melting operations a uniform mixing of metal can be relied upon. The reason this method of charging is adopted is due to the small holding capacity of the crucible and the necessity of having to tap out more frequently than would be necessary with a cupola of larger holding capacity. If the furnaceman charged the cupola indiscriminately, that is to say, if he put on a large quantity of pig-iron, then followed on with scrap, a metal with all the pig-iron and later metal all scrap would be obtained.

By following the method of charging a uniform mixture is made, whether the crucible is full or if there is only 2 or 3 cwts. in.

When the cupola is charged and the blast is put on, the tap-hole is left open until the metal commences to melt. About ½ cwt. of metal is allowed to run out before being stopped up. The reason for adopting this method is dual. In the first place, it ensures the tap-hole being thoroughly dry, due to the hot blast passing through; and, secondly, it communicates to the coke in the crucible a higher temperature, so that it does not affect the molten iron to any great extent. The metal, of course, is bound to lose some of its heat as it passes from the melting zone in its descent to the bottom, but up to the present with this cupola splendid metal has been obtained at the first tap.

This cupola has produced as clean casting from the first charge as at any other time of the blow, but at the same time they might be a little more difficult to machine.

When the metal first begins to melt it does not come down with the same rapidity as it does when the cupola has been in operation for some time, and it is more liable to become chilled in its descent to the bottom. When observing the melting through the tuyeres a drop of metal appears, and clings to the coke in front of the tuyeres for what might be a fraction of a second before proceeding to the bottom. This happens for a few minutes, but afterwards a small stream of metal runs continuously through to the bottom.

Coke Consumption.—The coke ratio that can be safely used depends on its quality. Undoubtedly, it is far safer to use a higher ratio and to obtain a good supply of hot metal than a low ratio and dull metal.

The following particulars give the results obtained with the cupola on a 13-ton 10-cwt. blow:—

Bed charge, 1,288 lbs.; 15 charges of 168 lbs. each, making 2,520 lbs.; 17th charge, 140 lbs.; 18th charge, 112 lbs.; total, 4,060 lbs.; less 560 lbs. recovered, gives 3,500 lbs. This works out at approximately 1 lb. of coke to 9 lbs. of iron. The time taken from putting on the blast to finishing was exactly three hours, giving an average of 4½ tons per hour. In the first two hours roughly 8½ tons, and in the last hour 5 tons were produced. The bed charge in the large cupola is 2 ft. 6 in. over the top tuyeres, which

may seem to be abnormally high, but lower beds have been unsuccessfully tried, as the metal comes down too dull. When the blast is put on it takes from 12 to 15 minutes before the metal makes its appearance at the spout, so that, taking the time from when the metal commences to melt, an average of 4¾ tons per hour is given. It is interesting to note that since taking this record many better results have been shown.

Flux.—The quantity of flux necessary varies with the quality of scrap that is being melted; for example, if rusty scrap is used the limestone should be increased by 20 to 30 per cent. Generally, 20 lbs. per 15 cwts. charge is used, the scrap being good, clean machinery and shop scrap, much of this latter having been cleansed in the rumbler. On the first two charges no limestone is used, the reason being that limestone, if used in the ordinary way of charging on the coke bed, trouble would be experienced with the open tap-hole, as the flux is the first to melt, and some of this would find its way to the bottom before the metal reached that zone, and being blown into the tap-hole, it would soon become solidified, not having the fluidity of the molten iron.

On a few occasions the slag that has solidified on the bottom of the cupola, after the cleaning out operations, when the blast has been put on has fused, has almost stopped up the tap-hole, and has caused trouble in keeping it clear. When the metal commences to melt it does not run so freely when this happens.

It might be said that the metal would not be clean on the first or second charge by following this method, but it has been proved on several occasions, by casting castings to be machined all over from the first charge, which have turned out satisfactorily and have machined up well.

Slag.—It has been said that a cupola slag that has a certain green colour denotes that ideal melting conditions are prevailing. On several occasions slag samples have been taken, and although there has been a decided difference in colour, no difference in the quality of the metal as to its fluidity and machining properties has been noticed. When operating the larger cupola a noticeable decrease in temperature takes place after about 7 tons of metal has been tapped out, therefore at this point the slag hole is opened for about 15 minutes to run off the slag. A few minutes after the slag has been removed a decided temperature increase takes place, and metal as hot as the first 4 or 5 tons of the blow is produced.

Though samples of slag from different blows have been preserved, the author fails to see what useful purpose it serves to a foundry manager or foreman who has had no laboratory training for the purpose of ascertaining the working conditions of a cupola.

A peculiar experience met with by the author was on an occasion when blowing for the day was almost finished and the slag had been run off in the usual way. It was then noticed that the bottom tuyeres were blowing out sparks, due to a thick slag running into the air belt. The metal in the cupola was immediately tapped out, which relieved the matter somewhat, but in two or three minutes the tuyeres were choked again. As the tuyeres could not be cleared, the blast was shut off and the bottom dropped. The next morning it was discovered that about fourteen bricks had been dislodged from the stack, and had fallen into the furnace before the last charge had been put on. The slag gathered up was very light in colour, spongy, and associated with particles of brick. In this case it was easy to tell by the slag that something was wrong.

Distance of Blower from Cupola.—Usually foundrymen prefer the blower or fan as near the cupola as possible, but it is possible to have the blower a good distance away and maintain a good blast pressure.

Trouble due to a No. 3 Roots' blower having an insufficient motive power and being in an exposed position in the fettling shop was experienced, as when the blast was put on with all tuyeres closed the coils in the switchbox fused. This blower was about 12 ft. from the first cupola, 24 ft. from the second, and 44 ft. from a small emergency cupola; all three were served by the one main pipe. This fusing happened twice at a time when the practice was to blow with one tuyere open, to take the load off the motor. By leaving the tuyere open the cupola would not be getting the full value of the blast, and to overcome this the excess pressure was allowed to pass off through the next cupola by opening the valve on that cupola and closing all the tuyeres. At the same time blast pressure was being lost, and this had to be rectified, as more load could not be put on the motor, so it was decided to get a larger one of 20 h.p., and at the same time remove the blower to a cleaner atmosphere. The most convenient place found was 86 ft. from the previous position, and it was doubtful whether sufficient blast could be obtained and its pressure maintained at such a distance.

On the advice of Prof. Rhead, larger diameter pipes were laid, the blower and the motor being fixed during a holiday time. No trouble was experienced in maintaining the blast pressure as previously, and better melting was obtained by being able to use all the blast in the cupola. Evidently it is possible to have a blower a good distance away, and still have an efficient volume of blast. When this cupola was in operation during the time that the tuyere was left open trouble was experienced daily by the removal of a large nodule of iron, slag and coke adhering to the cooled side of the cupola. The cause of this cooling was due to the tuyere on the opposite side being left open. The tuyere on the side that the nodule was formed carried the heat from that side through to the side where there was no resistance. Consequently, when the metal and flux began to melt and run down to the bottom some of it was cooled or frozen around the tuyere, and as the melting operation proceeded the slag, coke and metal accumulated, and formed the large "wart" difficult to remove. By opening the tuyere on the cooled side and closing the opposite tuyere, thus driving the heat to the cooled side, the size of the obstruction was diminished, but it was not completely successful.

The Small Cupola.—This cupola, shown in Fig. 2, has been in use with the one lining over six years, and is still in good repair, but, with one or two exceptions, it has only been used on Saturdays for small blow. Its dimensions are:—Diameter, 2 ft. 2 in.; height from bottom to charging door, 15 ft. There are eight tuyeres; the four upper ones are 3 in. round, and the four lower oblong, 4 in. by 2½ in. The ratio of the diameter to the height is 7 to 1. It will take four 10-cwt. charges, filling up to the charging door.

A record of a 5-ton blow, not taken under the best conditions, as obviously a fair test could not be obtained, as the cupola being cold requires heating up. Blast has generally to be put on when the fire is burned up just above first row of tuyeres. This was the case when this record was taken. The time taken to melt 5 tons was exactly 1 hr. 50 min. The metal did not appear until after 20 minutes' blowing, but came down fairly hot, though not so hot as the metal from the larger one. After tapping out 2 or 3 cwts., the metal was sufficiently hot to run any of the light castings.

The following particulars give the result with this cupola:—Bed charge=980 lbs.; 7 charges=784 lbs.; 9th charge=100 lbs.; 10th charge=100 lbs.; total, 1,964 lbs.; less coke recovered, 448 lbs.; giving 1,516 lbs.

The ratio is therefore 2 cwts. 2 qrs. 22 lbs. of coke per ton of iron melted, or approximately 1 lb. of coke to 7½ lb. of iron, and an average of 2½ tons per hour, but taking the time from when the metal appears at the spout, an average of 3 tons per hour.

With both these cupolas there is an advantage over cupolas with shorter stacks on account of the ability to put on four charges before starting blowing, and during the melting operations the descending charges get pre-heated before melting, which increases speed of working.

A decided disadvantage with these cupolas can occur if at any time a hang is set up, due to the furnace-man putting on large pieces of scrap,

XUM

which on heating up expand and catch the cupola sides.

Blast Pressure.—The blast pressure on this cupola is 15 ozs. on a mercury gauge, fixed on the top of the delivery pipe, which may be considered a hard blast pressure, and if a hard blast is responsible for hard castings, this cupola should produce unmachinable castings. On the other hand, particularly soft material is invariably produced.

The blast pressure is one of the many problems to be solved when the British Cast-Iron Research Association becomes active.

Table I.—*Approximate Analysis of Raw Materials.*

	G.C.	C.C.	Si.	S.	P.	Mn.
Denbigh No. 3 .. .. =	3.214	0.660	2.89	0.020	1.45	0.50
Thorncliffe, No. 3 .. =	2.710	0.320	3.04	0.260	1.31	0.57
Glengarnock, No. 3	3.250	0.250	3.00	0.050	0.60	1.00
Gartsherrie, No. 3 .. =	3.000	0.370	2.79	0.220	0.65	1.42
Ajax, No. 3 .. .. =	2.600	0.425	2.00	0.030	1.25	1.75
Lackenby, No. 3 .. .. =	3.500	0.080	3.31	0.029	1.43	0.70
Staveley, No. 3 .. .. =	3.200	0.300	2.90	0.013	1.50	1.75
Carnhoe, No. 3 .. .. =	3.450	0.300	2.75	0.048	0.93	0.10
Light machinery scrap	2.80	0.50	2.60	0.10	1.00	0.700
Semi-steel tank shell heads ..	2.05	0.96	1.98	0.18	0.61	0.430

Table II.—*No. 1 Mixing.*

	Lbs.	G.C.	C.C.	Si.	S.	P.	Mn.
Denbigh, No. 3 ..	200 =	6.428	1.32	5.78	0.040	2.900	1.00
Glengarnock, No. 3 ..	300 =	9.750	0.75	9.00	0.150	1.800	3.00
Staveley, No. 3 ..	150 =	4.800	0.45	4.35	0.019	2.250	2.62
Ajax	100 =	2.600	0.42	2.00	0.030	0.650	1.42
Scrap	750 =	21.000	3.75	19.50	0.750	7.50	5.25
		44.378	6.69	40.63	0.989	15.100	13.29
		2.958	0.44	2.71	0.065	1.007	0.88

tile castings are shown in the following tables:—

No. 1 mixture gives a soft, close grain iron, has good running properties, is easily machined, and is not liable to draw on the heavier sections of textile work, wheel boxes, etc.

No. 2 mixture results in soft grey-iron. It has good running properties, but requires watching for drawing in solid parts, and must not be run at too high a temperature. Lackenby was added to counteract the low Si in the shell-heads (1.98 per cent. Si).

With No. 4 mixing the percentages were altered slightly to see if the shrinkage given by No. 3 could be overcome. Better results were obtained, but the casting temperature had to be watched.

Table III.—*No. 2 Mixing.*

	Lbs.	G.C.	C C.	Si.	S.	P.	Mn.
Denbigh	150 =	4.821	0.99	4.33	0.030	2.17	0.75
Thorncliffe	250 =	6.760	0.80	7.60	0.650	3.27	1.42
Glengarnock	250 =	8.120	0.62	7.50	0.125	1.50	2.50
Ajax	100 =	2.600	0.42	2.00	0.030	1.25	1.75
Scrap	750 =	21.000	3.75	19.50	0.750	7.50	5.25
		43.301	6.58	40.93	1.585	15.69	11.67
		2.880	0.43	2.72	0.105	1.04	0.77

Table IV.—*No. 3 Mixing, with Tank Shell Heads.*

	Lbs.	G.C.	C.C.	Si.	S.	P.	Mn.
Glengarnock	200 =	6.50	0.50	6.00	0.050	0.60	2.000
Staveley	150 =	4.80	0.45	4.35	0.019	2.25	2.620
Ajax	100 =	2.60	0.42	2.00	0.030	1.25	1.750
Gartsherrie	100 =	3.00	0.37	2.79	0.220	0.65	1.420
Lackenby	200 =	7.00	0.16	6.62	0.058	2.86	3.500
Shell heads	200 =	4.10	1.92	3.96	0.360	1.22	0.868
Scrap	550 ..	15.40	2.75	14.30	0.550	5.50	3.850
		43.40	6.37	40.02	1.287	14.33	1.600
		2.89	0.43	2.66	0.085	0.95	1.000

Table V.—*No. 4 Mixing.*

	Lbs.	G.C.	C.C.	Si.	S.	P.	Mn.
Glengarnock	200 =	6.50	0.50	6.00	0.050	0.60	2.00
Staveley	200 =	6.40	0.60	5.80	0.026	3.00	3.50
Ajax	100 =	2.60	0.42	2.00	0.030	1.25	1.75
Lackenby	150 =	7.00	0.16	6.62	0.058	2.86	1.40
Gartsherrie	100 =	3.00	0.37	2.79	0.220	0.65	1.42
Shell heads	150 =	3.07	1.44	2.97	0.270	0.91	0.64
Scrap	600 =	16.80	3.00	15.60	0.600	6.00	4.20
		45.37	6.49	41.78	1.254	15.27	14.91
		3.02	0.43	2.78	0.083	1.01	0.99

Mixing of Metal.—The quality of the pig-iron used for producing machinable castings is important, and it is futile to rely on one or two brands, as often in different consignments of the same brand of pig-iron different analyses are shown. It is advisable to use four or five different brands.

If every foundry had a chemist to check the analyses of pig-iron much trouble in the production of castings would be avoided. There are 3,000 foundries in this country, a large percentage of which do not employ a chemist, and have to rely solely on the approximate analysis of pig-iron supplied by the makers for making up cupola charges, with varying results.

The calculations for the mixings for light tex-

The "Wadkin" Mechanical Wood Worker.

It is an established fact that the pattern shop is regarded by many engineers as an unwelcome necessity. The nature of the work involves hand labour and processes so different from the ordinary principles of manufacture that conditions are tolerated in this trade that would be viewed with grave concern in others. In pre-war days, when the labour in the pattern-shop was more plentiful,

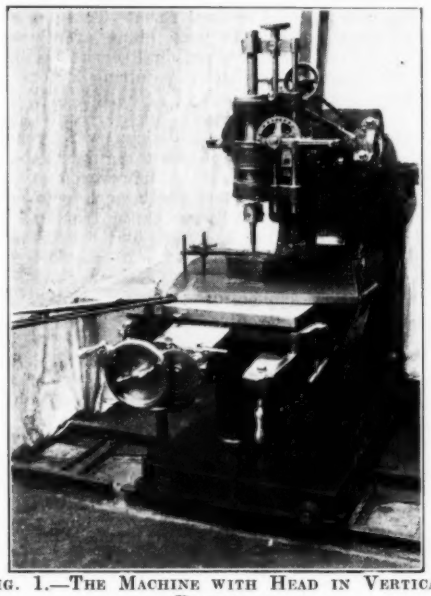


FIG. 1.—THE MACHINE WITH HEAD IN VERTICAL POSITION.

it was—except in the case of large engineering firms—generally considered sufficient to instal what might be termed "modern" type of wood-working machinery. To-day pattern-shop labour scarcity has doubled the trials of the firm whose pattern-shop has been undeveloped and neglected.

It is generally known that in a pattern-shop no two jobs are alike, and the principles of manufacture which apply to repetition wood-work are out of the question. A machine to operate on bends and irregular cuts of patterns and core-boxes, where probably only a single cut is required, must conform with certain well-defined

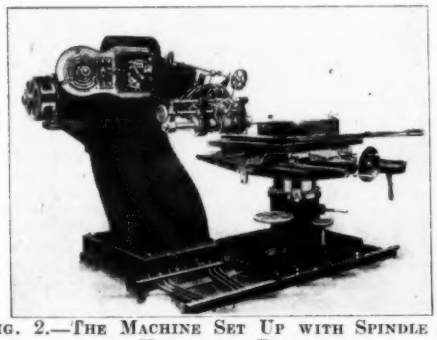


FIG. 2.—THE MACHINE SET UP WITH SPINDLE IN THE HORIZONTAL POSITION.

requirements. Firstly, the machine must be sufficiently flexible to give a combination of simple movements which will readily, economically, and conveniently operate upon geometric and irregular patterns with the infallible accuracy of mechanical control. Secondly, owing to the ever-varying details of pattern work and the fact that in many cases only single cuts are required at one setting, the machine must possess an effective range of simple adjustments, quick action, fine positive feed motions, and highly standardised tools to avoid scheming out and preparing temporary rigs and cutters. Thirdly, the whole equipment must be instantaneously adaptable to work of any nature and bring all movements and operations well within the grasp and manipulation of an average workman.

The machine known as the mechanical wood-worker, manufactured by Messrs. Wadkin & Company, of Leicester, which we illustrate, has been specially developed to fulfil the above requirements. In Fig. 1 the machine is shown set up in its vertical position, while in Fig. 2 the machine is set with the spindle in the horizontal position. In Fig. 2 the overhanging arm is deflected, and the spindle head is in the horizontal position. This overhanging arm floats up and down on sensitive bearings, and gives a range of movement such as will allow it being raised above its horizontal position or depressed until the spindle is below the level of the work table. A taper plunger pin ensures the arm being instantly set to its dead horizontal position, and a suitable locking device,

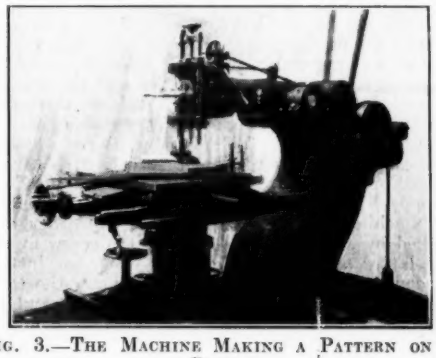


FIG. 3.—THE MACHINE MAKING A PATTERN ON A BEND.

within easy reach of the operator, fixes the arm at any desired angle. The floating of the overhanging arm whilst the cutter is running, enables irregular moulded work to be carried out, and gives a range of useful cuts. The spindle head swivels between the vertical and the horizontal, and can be instantly locked at any angle. The principal angles are mechanically located by a spring plunger-pin and intermediate angles located by index. The cutting spindle which runs on two double-row ball bearings can be rotated in either direction, thus enabling the cutter to work with the grain of the wood, and a reversing lever is so

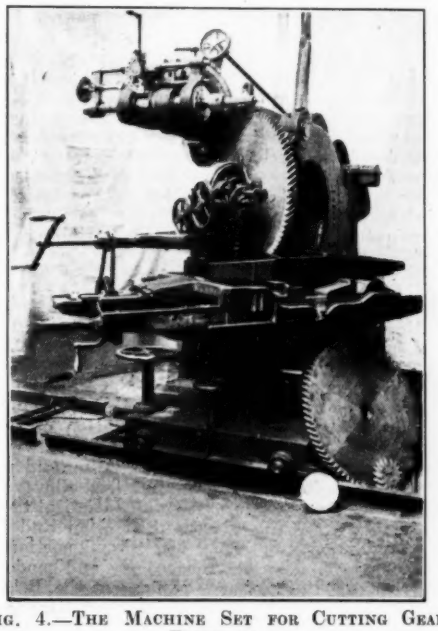


FIG. 4.—THE MACHINE SET FOR CUTTING GEAR PATTERNS.

placed that it is unnecessary for the operator to alter his position when reversing the direction of rotation.

Two independent motions are provided for feeding the cutter spindle into the work, one being a quick motion by hand lever while the other is a fine screw adjustment by handwheel. Both motions can be locked and stopped mechanically where desired. The cutter spindle has three speeds to suit the various sizes and types of cutters used. It is

driven by belt over suitably-placed guide pulleys from a shaft at the back of machine, the latter being driven by a countershaft. When required, the machine may be driven by a variable-speed motor mounted on a bracket at the back of the machine. By this arrangement the back shaft is replaced by the motor, thus making the machine quite self-contained.

Fig. 3 illustrates a specimen of pattern-making which is a most simple machine operation, but difficult hand work. Wrought by hand, a considerable amount of labour and skill is involved in obtaining an accurate finish, especially with S or swan-neck bends. The cuts are essentially mechanical cuts, and the machine operates on such bends of various radii and complicated forms by a simple semi-automatic movement which guarantees accuracy. For this sample the timber is roughly cut on the band saw to the approximate shape; the machine table is then set to the correct radius by traversing the table slide the required distance from the cutter spindle, and the work is shaped up as shown in the illustration. The cutter cleans up both the inside and outside of the pattern. The work table is of a heavy pattern, and is provided at regular intervals with tapped holes for securing the adjustable holding-down cramps. It has right-angle motions, one operated by machine-cut rack and pinion, the other controlled by screw and handwheel; the screw nut of the latter motion is split, and can be instantaneously opened or closed. This allows the table to be operated by the screw or floated to and fro by hand. The table can be turned in a complete circle, and locked when required, and can be raised and lowered by screw gear actuated by handle within easy reach of the operator. The pattern bend shown in Fig. 3 is being dealt with upon an auxiliary table. This auxiliary table turns about a fixed centre pin, and can be used for all small work, such as bends and sweeps up to 18 in. radius. The table is operated by a hand lever fitted with a spring plunger taper pin engaging in holes suitably placed in the main table, so that all the principal angles are mechanically obtainable: an adjustable locking bar secures the table at any intermediate angle. The working surface of the auxiliary table is marked out in such a manner that it is not necessary to set out any of the work with the exception of the two right-angle centre lines.

One of the most difficult and expensive hand operations in pattern-making, requiring no small degree of intelligence, skill and training, is gear cutting. This work is by far the most costly and intricate process to be found in the shop, and involves considerable time and labour to get even approximately accurate results by hand. An example of the mechanical method of cutting patterns for gears by the machine under notice is shown in Fig. 4. The machine is operating on a helical wheel and pinion; this was completed in 38 minutes, which time included setting up the machine.

LEAD ORES.—A "Monograph on Lead Ores," by Mr. T. C. F. Hall, M.Inst.M.M., F.G.S., has been published by John Murray (price 6s.) It is one of the series issued under the direction of the Mineral Resources Committee of the Imperial Institute. The first portion of the work principally comprises the following:—A description of lead-bearing ores and minerals; the valuation and smelting of lead ores; the refining, marketing and properties of lead; a description of lead-alloys and lead pigments. It contains several statistical tables and diagrams of the world's production and imports and exports of lead. The second portion of the monograph describes the geology and mode of occurrence of the lead ore deposits of the British Empire, including those in the United Kingdom: at Bawowin, in Burma; in British Columbia; and at Broken Hill, in New South Wales. The last portion is devoted to foreign countries, and describes the more important deposits of Germany, Italy, Spain, Upper Silesia, Mexico and the United States. The last-named country is far the largest producer of lead in the world, and sixteen pages of the work are devoted to the American deposits. A map is given showing the positions of the chief deposits of the world, and the book concludes with a bibliography.

Health in Brass Foundries.

According to results of investigations carried out by the United States Public Health Service into the health conditions prevailing in the brass and iron foundries of New Jersey and New York, the chief hazards of foundry work are those associated with production processes, including high temperatures, which are essential in parts of the plants; of smoke, gas, and fumes, which are evolved in sundry phases of the work; and of dust, liable to be noxious, which is produced abundantly in the sandblast, tumbling, and grinding rooms, where castings are reduced to final form. To these risks are added those due to poor plant architecture, inadequate or unsanitary personal service facilities, and unhygienic conditions resulting from inadequate lighting and lack of attention to cleanliness in workrooms, windows, globes, and similar essentials. All of these conditions were studied closely and tentative protective regulations have been devised. Chief attention, however, was given to the fumes and the dust, which were believed to be the factors most likely to cause trouble. The investigation made of the sand-blast process and its effects was probably the most complete ever made. All the data have not yet been assembled; but preliminary conclusions indicate that industrial hygiene can no longer be considered merely as a matter of sanitation but must be widened to include fundamental factors associated with plant processes and the materials used therein.

Reactions in Gas Producers.

At a meeting of the Newcastle Chemical Industry Club on the 9th inst., DR. J. H. PATERSON (President of the Newcastle Section of the Society of Chemical Industry) described the generally accepted views regarding the reactions which take place in gas producers, and indicated what effect these reactions had had on the design of producers in the past. He pointed out that if high enough temperatures were attained the first product of the reaction between air and carbon would be carbon monoxide only—which was not the theory usually held. That fact allowed for the use of thin fuel beds, provided fuel consumptions of over 40 lbs. of carbon per sq. ft. of grate area were attained. It was unfortunate that there should be practically no reliable data concerning the rate of reaction between red-hot carbon and steam. Nor was there much known as to the equilibrium of carbon monoxide, hydrogen, and steam mixtures. It was quite definite that the rate of reaction between steam and the incandescent carbon was slower than that between air and incandescent carbon, so that considerable quantities of steam might pass through a thin fuel bed without alteration even at the highest temperatures. That meant, in short, that the quantity of steam required to produce a given hydrogen content in producer gas varied not only with the temperature of the fuel bed, but with the thickness of the bed employed.

On the question of the formation of clinker in furnaces and gas producers, Dr. Paterson pointed out that if an ideal fuel bed could be provided in which the resistance to the passage of air was the same in all directions, the tendency to form clinker would be reduced to a minimum. The part played by incandescent surfaces of mineral matter in fuel in determining local temperatures required a good deal of investigation. It was quite common to find in a mass of hotly-fused clinker that portions having high melting points were fused, whereas low-melting-point portions remained in their original condition.

Dealing with the design of producer grates, Dr Paterson showed that the common system of central distribution, by producing uneven fuel bed temperatures, resulted in poor gas and bad clinkering. The ideal grate was a flat one of the maximum width of the producer, and with rocking firebars so designed as to give equal motion throughout the entire bed. Such a grate, combined with thin fuel bed and a non-caking fuel, should result in the production of good gas and freedom from clinker troubles.

It is suggested by the "Fondern Moderne" that small foundries can reclaim brass from cinders by crushing in a tumbling barrel and "washing" the crushings, or if the loss of zinc is not important, by remelting in the cupola with a lime slag. If such brass is cast hot it can be used for unimportant castings.

Trade Talk.

MR. R. T. ROLFE read a paper on "Gunmetal" before the members of the Institute of Metals (Birmingham Section) on Tuesday.

A MYSTERIOUS fire occurred last week at Rawdon Foundry, near Ashby-de-la-Zouch. Three fire brigades succeeded in saving the main works, but all store rooms were gutted.

BEFORE the Sheffield and District Section of the Junior Institution of Engineers, a paper was read by Mr. J. Benson, at the Cutlers' Hall, on "Sheet Metal Working Machinery."

"MODERN Boiler House Operation" was the subject of a lecture by Mr. M. Cohen, of York, on March 18, before the members of the Sheffield branch of the Association of Engineering and Shipbuilding Draughtsmen.

THE meeting of the Coventry Branch of the Institution of British Foundrymen, announced to take place on April 6, has been cancelled. The annual meeting, followed by a smoking concert, will take place on April 8.

THE Board of Trade (Licensing Section) announce that licences are no longer required for the export to Russia of any goods other than goods the export of which is prohibited, except under licence to all foreign countries.

IT was announced by Mr. Tom Mann, the retiring secretary of the Amalgamated Engineering Union, that the result of the ballot in the election of his successor had been as follows:—Mr. A. H. Smethurst, 56,761; Mr. J. Kaylor, 40,346.

THE question of the revision of the wages of the brassworkers in Birmingham was debated at a meeting of the Conciliation Board at 110, Edmund Street, on the 18th inst. The proceedings were adjourned, no decision having been arrived at.

THE United Kingdom plays a very small part in the world's production of spelter. According to statistics the world's total last year was 698,875 tons, to which the United Kingdom contributed only 14,766 tons, with an additional 7,585 from refiners.

AT a meeting of the Sheffield Association of Metallurgists and Metallurgical Chemists, held on March 15, an interesting lecture on nickel-chromium steels was delivered by Mr. J. H. S. Dickenson. The meeting was presided over by Mr. P. B. Henshaw.

HERR STINNES has concluded an agreement whereby 200,000 shares in the Alpine Montan Gesellschaft, Austria's great iron-ore company, pass into his hands. The sellers are the Italian Fiat Motor Company, which bought 250,000 Alpine shares in 1919.

THERE is evidence that conditions in the American steel industry are changing for the better, says the Central News. The United States Steel Products Company has received orders for 2,400 tons of steel rails for India and 1,100 tons of steel plates for Australia.

A MEETING of the West of Scotland Iron and Steel Institute was held in the Royal Technical College, Glasgow, on Friday last, Mr. A. Gray presiding. A Paper on "Developments of Iron and Steel Manufacture in South Africa and Australia" was read by Mr. W. H. Herdman.

A NEW schedule involving a reduction of bonuses payable to boys up to 21 in the engineering and allied trades in the Birmingham and Wolverhampton area has been accepted by a majority of trade unions concerned, and the new rates come into force on the first pay day after last Monday.

PROFESSOR A. M. LOW announces that a committee has recently been formed to go into the question of alcohol production in England for power purposes, as the supply is practically inexhaustible, and would undoubtedly be seriously treated by the Government, if any quantity production scheme was brought forward.

SOUTH WALES SIEMENS STEEL ASSOCIATION and the Iron and Steel Confederation, at a conference held at Swansea recently, decided upon a sliding scale wage arrangement for process men throughout the trade. By this arrangement the wage principle is now settled for the whole Welsh steel trade, and all trouble is averted.

IT is understood that the judgment of the French Court at Metz has been given in favour of the British iron and steel manufacturers, who, it will be remembered, brought an action against the sequestrator of the Lorraine Iron and Steel Works for breach of contract. Full details of the judgment have not yet been received.

MR. FELIX J. BLAKEMORE, president of the National Chamber of Trade, speaking at the annual meeting of Belfast Chamber, said the whole world was in urgent need of the goods they made, but, unfortunately, had not the money to buy them. The urgent need, in order to rehabilitate industry, was to reduce the cost of production.

WHAT seems to be a promising deposit of lead and vanadium occurs in the Marico district of the Transvaal, on the Doornhoek lead mine. Samples analysed by Dr. James Moir, the Government Mining Chemist, indicate a content ranging from 8.15 to 15.5 per cent. of lead metal and from a trace to 1.35 per cent. of vanadium pentoxide.

AT a meeting of the North Shields No. 1 Branch of the Boilermakers' Society, the employers' demands for a reduction in wages was considered. The following resolution was adopted: "That we support our Executive Council in pressing for a public inquiry into the condition of the shipbuilding industry before the employers attempt to reduce wages."

SPAIN has derived benefit from our war experience. The work of our big naval guns on the "Queen Elizabeth" and other battleships so impressed the Spanish Naval authorities that they have decided to place 18-in. guns on their latest type of battleship. A leading Sheffield firm, which made the "Queen Elizabeth" guns, has been successful in securing the order.

A PROVISIONAL agreement has been made in the edge-tool trade in the Birmingham area, under which bonuses paid to workpeople are to rise and fall with the cost of living on the basis of the Board of Trade figures. The agreement will apply to Birmingham, Wolverhampton, Cannock, Wednesbury, Old Hill, and Stourbridge districts, and will affect about 5,000 workpeople.

BEFORE Mr. Justice Roche, in the Commercial Court in the King's Bench Division, London, on the 16th inst., Nicholls Brothers, of Milan, sued the Falkirk Iron Company for alleged breach of contract to sell 504 baths at £5 6s. each f.o.b. Glasgow for shipment to Italy in January, 1920. In the result plaintiffs were awarded £500 damages, judgment for whom was entered with costs.

IN the course of a discussion on a paper entitled "Cupola Practice" read before the members of the Sheffield and District Institute of Foundrymen by Mr. W. Rawlinson, of Manchester, Mr. John R. Hyde, president of the Branch, complained of the quality of the coke now being supplied to the foundries. "It appeared to him," he said, "that some people thought anything was good enough for the foundries."

IT is reported that the Public Works Department of the New Zealand Government has recently awarded the Cleveland Bridge and Engineering Company, Limited, of Darlington, the contract for the steel work required for the seven-span plate-girder bridge over the Hope River, and for a seven-span bridge for the Midland Railway of New Zealand, and a single-track bridge at Bealey, on the Arthur's Pass section.

ALDERMAN GREGORY presided in Birmingham at an adjourned conference of the employees' delegates from the whole of the works in Birmingham and the Black Country affected by the dispute in the nut and bolt trade. The Chairman reported that a largely attended meeting had been held at Darlaston, at which a resolution to resume work on the employers' terms, as contained in their letter of March 10, had been agreed to.

MR. WILLIAM CLARKE, of Vickers, Ltd., Master Cutler of Hallamshire, speaking at a luncheon given by the president of the Sheffield Exchange, said if the Government would only come to a settlement with British railway companies and allow them to know where they were, manufacturers could quickly get orders for rails. All the railway companies were needing rails, but at present they had no money, and they did not know what their prospects were.

THE HOME SECRETARY has made orders in respect of the undermentioned firms authorising the employment of certain workers on two day-shifts, subject to certain conditions:—W. & T. Avery, Limited, Soho Foundry, Smethwick: Women of 18 and lads of 16 years engaged in the Automatic Machine Department; British Aluminium Company, Limited, Bank Quay, Warrington: Women of 18 years engaged in connection with the making of aluminium sheets and tubes.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS has issued new regulations relating to the 1921 scholarship. The alterations may be summarised as follows:—(1) The subjects for the examination are different, and are three in number instead of six; (2) candidates for the scholarship who have not already satisfactorily passed an examination of approved matriculation standard may enter for a matriculation examination along with the scholarship examination.

A SHEFFIELD report states that trouble in the foundry industry is brewing among the members of the Moulders' Union as a result of the recent embargo by the National Executive and the local branches on piece-work and bonus systems. Several men who have been working under these conditions, and who by throwing them over would lose from £1 to £3 per week, have refused to obey the Union dictum, and have been fined £2, and then £3, and the next step proposed is exclusion. Attempts are being made to challenge the right of the Executive to do this.

IRON AND STEEL INSTITUTE.—The annual meeting of the Institute will be held, by kind permission, at the Institution of Civil Engineers, Great George Street,

Westminster, on Thursday and Friday, the 5th and 6th of May, 1921, commencing each day at 10 a.m. Programme of proceedings:—Thursday, May 5, 10 a.m.—General meeting of members. The Council will present their report for the year 1920. The hon. treasurer will present the statement of accounts for 1920. Scrutineers will be appointed for the examination of voting papers. Election of Council. Resolutions, formal notice of which was given at the autumn meeting, on September 21, 1920, for the alteration of by-laws 21 and 22, relating to annual subscriptions will be submitted. A selection of Papers will be read and discussed (Nos. 2, 10, 8, 3, 4). 2.30 p.m.—Afternoon session. 7 for 7.30 p.m.—Annual dinner of the Institute in the Grand Hall of the Connaught Rooms, Great Queen Street, W.C. Friday, May 6:—10 a.m.—General meeting of members. The award of the Andrew Carnegie Research Scholarships for 1921 will be announced. A selection of Papers will be read and discussed (Nos. 1, 6, 7, 12, 11). 2.30 p.m.—Afternoon session. Autumn meeting.—An invitation has been received from the Comité des Forges de France for the Institute to hold its autumn meeting in Paris early in September. After the meeting arrangements will be made to enable members attending to visit works in Lorraine, Creusot and Normandy.

Personal.

THE late Mr. R. Hodges, of Rowland Hodges, Limited, brassfounders, Birmingham, left £10,459.

THE late Mr. R. Cowan, managing director of Brigham & Cowan, Limited, South Shields, left £75,481.

MR. ROBERT COWAN, of Holmcroft, Westoe, South Shields, managing director of Brigham and Cowan, Limited, graving dock proprietors and engineers, South Shields, left £75,481.

MR. F. B. PERRY, chief engineer of Robey & Company, Limited, and Commander C. C. Sherman, the company's London representative, have been elected directors of the company.

MR. F. H. HATCH, Ph.D., M.Inst.C.D., has been appointed by the Secretary of Mines to be technical adviser to the department on questions relating to the metalliferous mining industry.

MESSRS. GOODWIN & COMPANY have removed their contractors' supplies department from 53, Queen Street, Sheffield, to 77-79, Penistone Road, Sheffield. This department deals with rails, railway and contractors' plant.

MR. B. MOUATT JONES, M.A., who has been Professor of Chemistry and Director of the Edward Davies Chemical Laboratories, Aberystwyth, since October, 1919, has been appointed Principal of the Manchester College of Technology by the Manchester Education Committee.

AT the annual meeting of the National Federation of Iron and Steel Manufacturers, in London, Sir Frederick Mills was elected President, and Messrs. W. Clark, John Craig, and A. Dorman, vice-presidents. The retiring President, Mr. G. Scoby-Smith, was elected Past President.

Company News.

Sir W. G. Armstrong, Whitworth & Company, Limited.—Dividend on ordinary shares for half-year to December 31 last of 1s. per share, making 2s. per share for the year, less tax. The usual dividends on the first, second, and third preference shares will also be paid.

Sir William Arrol & Company, Limited.—The report for 1920 shows profit, including £16,193 brought in, of £81,336. Directors recommend placing to depreciation fund £15,000, fund for equalising dividends £10,000, and a dividend of 10 per cent. on ordinary shares, free of tax, carrying forward £10,623.

Barrow Bolt & Engineering Company, Limited. — Capital £10,000. Directors: G. B. P. Thompson, H. G. Butchart and F. Butler. Secretary: G. B. P. Thompson.

Bevan & Company (Iron and Brass Founders), Limited.—Capital £10,000 in £1 shares, to take over the business of iron and brass founders carried on by H. Bevan, T. J. Bevan, and W. Lloyd, at Canalside Wharf, Neath, Glam., as Bevan & Company. The permanent directors are: H. Bevan, T. J. Bevan, and W. Lloyd. Secretary: W. Lloyd. Registered office: Canalside Wharf, Neath, Glam.

Brierley's Premier Welding Company, Limited. — Capital £3,000. Directors: W. Brierley, Florence Brierley, T. C. Evans, and F. A. Bradley.

British Aluminium Company, Limited.—A final dividend of 6 per cent., making 10 per cent. for the year, is announced, leaving £19,534 to carry forward.

Carrier Engineering Company, Limited. — Capital £25,000 in £1 shares. Registered office: 24, Buckingham Gate, S.W.

Cartvale Engineering & Foundry Company, Limited.—Capital £25,000 in £1 shares. Registered office: 61, New Sneddon Street, Paisley.

Robert Heath & Low Moor, Limited.—The report for 1920 shows profit, including an amount for coal awards, 1917 to 1919, of £336,674, plus £61,150 brought forward. Debenture interest and depreciation, £106,489; transferred to taxation reserve £115,000, and to capital reserve (bringing reserve account to £347,993), £24,000; dividend of 10 per cent., subject to tax, payable April 30; carrying forward, £82,335.

"Lessfyre" Engineering Company, Limited. — Capital £3,200 in 3,000 ordinary shares of £1, and 4,000 deferred shares of 1s. each. Managing director: G. Norris. Registered office: 124, Chancery Lane, W.C.

Mottram Brothers, Limited. — Capital £2,000, to carry on the business of engineers and machinists, etc. Directors: G. G. Mattram, J. J. Mottram, and G. Mottram. Registered office: Acme Works, Water Street, Hurst, near Ashton-under-Lyne.

Nettleham Tractor & Engineering Company, Limited.—Capital £10,000. Directors: P. D. F. Ferreira and W. T. Meyrick. Registered office: Nettleham, Lincoln.

Paterson Hughes Engineering Company, Limited.—Capital £4,000 in 2,500 preference and 1,500 ordinary shares of £1 each, to acquire the business of Thomson-Knox Company, engineers, 36, Charlotte Lane, Glasgow. Registered office: 36, Charlotte Lane, Glasgow.

Robb Bros., Glasgow, Limited.—Capital £3,000 in 500 preference shares and 2,500 ordinary shares of £1 each, to carry on the business of engineers, etc. Registered office: 27, Oswald Street, Glasgow.

Henry Rogers Engineering Company, Limited. — Capital £30,000 in £1 shares, half allocated as capital of Brazilian branch. Directors: L. H. Twentyman, H. E. Twentyman, and A. H. Twentyman. Registered office: Union Street, Wolverhampton.

Steel Company of Canada, Limited.—Dividend of 1¾ per cent. on preference, and dividend of 1¾ per cent. on ordinary for quarter ending March 31.

Wirral Brass Foundry, Limited. — Capital £100. Permanent directors: P. J. W. Roberts (managing director), and J. R. Jones. Registered office: 35, Duncan Street, Birkenhead.

Deaths.

THE death has occurred in his 79th year, after a short illness, of Mr. William Johnston, who has been connected with the firm of R. & W. Hawthorn, Leslie & Company, Limited, at their Forth Banks Locomotive Works, Newcastle, for over 60 years.

MR. JOHN M'KENZIE died at his residence at Auchintore, Whifflet, on March 14. The deceased gentleman was the manager of the Speedwell Iron Works, Coatbridge, of Wm. Beardmore & Company, Limited.

Gazette.

A WINDING-UP order has been made against the United Engineering Utilities, Limited, 456, High Road, Chiswick.

A PETITION for the winding-up of the Stoic Steel and Tool Company, Limited, will be heard in Sheffield on April 7.

A PETITION for the winding-up of the Glendinning Antimony Mines, Limited, will be heard in London on April 12.

THE BRITISH METAL REDUCERS, LIMITED, are being wound up voluntarily. Mr. H. Morgan, 17, Eldon Street, E.C.2, has been appointed liquidator.

MESSRS. W. L. FERGUSON and A. E. Ryeland, electrical engineers and contractors, 44, Weston Street, London Bridge, S.E.1, trading under the style of Ryeland & Ferguson, have dissolved partnership. Mr. A. E. Ryeland continues.

THE partnership lately subsisting between Messrs. F. S. Ormerod, J. Tierney, and J. Wood, trading under the style of Tierney, Wood & Company, electrical engineers, 484, Oldham Road, Failsworth, near Manchester, has been dissolved so far as regards Mr. F. S. Ormerod.

THE partnership heretofore subsisting between Messrs. J. A. Whittaker, A. Chippendale, and B. Buckley, iron and brass founders, Jane Street, Rochdale, under the style of the Rochdale Brass Company, has been dissolved. Messrs. A. Chippendale and B. Buckley will continue the business.

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THE WAR SHOWED YOUR
ABSOLUTE DEPENDENCE ON
FOREIGN SANDS

☛ THE SAME WAR SET YOU FREE

and provided you with an All-British Sand freely admitted by British and even some Belgian Steel Founders to be better in every way than any imported Sand, and known the country over as

"YORKSHIRE SAND"

which strips cleaner, needs less nails, carries greater weights, is more regular, stands more mixing sand than any French or Belgian Sand on the market, and is

CHEAPER IN EVERY WAY.

Why return to the Foreign Yoke?
Why create more unemployment at home?
Why send British money out of the country?

THE GENERAL REFRACTORIES Co., Ltd.
KELHAM ISLAND, SHEFFIELD,

Telephone: 3577 (2 lines) *Telegrams: Refractory, Sheffield*

WILL BE PLEASED TO DEMONSTRATE TO YOU

(1) *The Best way to use "Yorkshire Sand."*
(2) *That it is cheaper than any Foreign Sand.*
(3) *That it is better in every single respect.*

YORKSHIRE SAND IS SUPPLIED IN 4 GRADES.

"EXTRA STRONG" as a binder for Silica Sands which we can supply cheaper and better than anyone else.

"STRONG" for large work, and to be let down for medium and small castings.

"ORDINARY" for medium stoved work, and may be let down for small castings if desired.

"GREENSAND" ready for use for Skin-dried, Greensand and Light Stoved Work.

IRON AND STEEL MARKETS.

Pig-Iron.

The outlook in the Cleveland iron market is distinctly more hopeful, the long anticipated reduction in fuel costs having at last materialised, the coke makers having definitely decided to free the trade, with the result of a big decrease in the selling price at ovens, which must eventually largely influence the downward tendency of pig values in the near future. It may be, however, pointed out that the last reduction in pig-iron prices was made in anticipation of relief in regard to fuel costs, and that no further concessions can be expected on this account. At all events, none were made in last week's market, and as there will be presumably no meeting until after the holidays, the situation may not again be reviewed until April, when possibly circumstances may permit of a further drop in pig-iron prices. It is, in fact, more than probable that some price cuts will be made in April, for we shall then get a wages adjustment, both in the ironstone mines, the coal mines, and the blast-furnaces, and working costs all round will be reduced. Meanwhile, prices are unchanged at 155s. for No. 1 and silicious iron, 150s. for No. 3 Cleveland G.M.B., 149s. for No. 4 foundry, 147s. 6d. for No. 4 forge and mottled, 145s. for white, all for home consumption, with 5s. per ton premium asked for export. Reports current on 'Change suggested that one or two second hands have sold at less than these prices, but the ironmasters refuse to do so, even though the export trade has practically vanished, and the home demand is insufficient to absorb even the limited quantities of iron now on the market. In the Lancashire pig-iron market there is little opportunity of testing the reality of prices, but so far it appears that the Derbyshire makers are still trying to keep the price at £8 10s. to £9 per ton on trucks. Northamptonshire foundry iron might probably be had at £8 on trucks, but this is still dearer than Cleveland for delivery in Manchester. Staffordshire foundry pig-iron is in much the same position as Derbyshire. Forge pig-iron is cheaper, of course, but consumers show no disposition to buy it, at any rate in Lancashire. In the West of Scotland the pig-iron market is practically at a standstill, and conditions are in a precarious state in this industry. The demand is of very little account, and makers cannot go on producing material for stock alone at present cost of output. Scottish No. 1 foundry is £8 15s., and No. 3 foundry £8 10s., all per ton delivered Glasgow area. These quotations, however, are altogether out of it in comparison with Continental levels. In South Staffordshire consumption of pig-iron is at very low level and markets are unusually stagnant, expansion depending very much on the development of the fuel situation. For the present pig-iron producers appear to have checked Continental competition by the cuts they have made, but consumers are not buying more than they are obliged in anticipation of still further concessions. With most of the furnaces blown out or damped down, the output is not greatly in excess of diminished district requirements. Smelters quote £8 for forge, and £8 10s. for No. 3 foundry, but these figures are practically nominal. Northamptonshire forge has been offered at £7 delivered in the district; cases are mentioned of prices below this level. Foundry qualities are relatively strong. Derbyshire quotations are nominally £8 for grey forge, and £8 10s. for No. 3 foundry.

East Coast hematite is now more or less a drug on the market, but the price is unchanged at 180s. per ton for mixed numbers, and 182s. 6d. for No. 1, and as the Italian exchange has undergone a sharp rally there seems to be a little brighter hope of foreign business. The outlook in the Cumberland and North Lancashire hematite pig-iron trade has not been improved in any important degree by the recent reduction in prices, and it is quite clear that the situation will remain unchanged until demand expands. The present position is that with ordinary iron at £9 per ton they cannot smelt iron except at a loss of between £2 and £3 per ton, and that being so they are making only the ordinary iron that is absolutely necessary for their ironworks, or the low phosphorus iron that is needed to complete contracts.

Ore.

The Tees-side foreign ore trade is absolutely idle. Nobody attempts to do business, and it is difficult to fix even a nominal price, though 37s. 6d. per ton c.i.f. is suggested as a nominal figure for best rubio ore. Reports from the Spanish ports confirm the fact that the slump is not merely local, and one day recently there was not a single ore ship loading at Bilbao—an event unparalleled in recent years. In North Lancashire and West Cumberland there has been a cessation of activity in the ironstone industry consequent upon the falling away in the demand, and the mines of the Barrow Hematite Steel Company, at Park, Yarlside, and Anticross, and the Newton Mining Company's pits have been closed down, except for pumping operations. The Roan Head Mines are on short time. The Hodbarrow Mines are again closed. Prices are unchanged, with native ores at 49s. to 60s. per ton net at mines. Spanish ores are at 38s. per ton, delivered.

Scrap.

Contemporary with the slackness in pig-iron markets, business in all kinds of scrap material is virtually reduced to a vanishing point, foundries, among the chief consumers of this form of metal, having as a rule sufficient stocks in hand, or bought in advance, to satisfy visible requirements till the period of depression has passed. In the absence of buyers scrap prices continue to develop further weakness, quotations in the Welsh market last week ruling as follows:—Heavy steel scrap, £4; steel turnings, £2 10s. to £3 10s.; bundled steel scrap and shearings, £4; mixed wrought iron and steel scrap, £1 10s. to £4 10s.; heavy cast-iron scrap, furnace sizes, £5; good machinery scrap, £7 to £8.

Steel.

In view of the holidays now in full swing there is little fresh to report in the conditions of the Sheffield steel industry, business being entirely suspended, with every prospect of an extended vacation in most branches. The outlook, as far as the immediate future is concerned, can hardly be regarded as encouraging, most of the firms still working having nearly completed contracts in hand without much prospect of an early replacement by fresh orders. The more optimistic members of the trade are, however, looking forward with sanguine hopes of a re-opening of business relations with Russia now the agreement has been signed, and there can be no doubt that that distressful country is urgently in need of large quantities of steel material which Sheffield can provide, but the question of payment for the goods supplied is not yet sufficiently assured to inspire confidence in dealings on a large scale through the medium of the Government now in power in Baltic territory. In the meantime the downward tendency in prices of steel and semi-products continues unchecked, one of the latest items being bright drawn qualities, which have been reduced a further £7 per ton, while quotations for wire rods, cold rolled strip, and other material are again lower. The production of steel ingots in the Sheffield district in January was as follows:—Open-hearth acid, 24,000 tons; open-hearth basic, 26,000 tons; Bessemer acid, 12,000 tons; Bessemer basic, 6,000 tons; castings and other ingots, 3,000 tons—total, 72,000 tons, against a monthly average during last year of 154,000 tons. The English and Scottish steel makers have now agreed to work to a uniform list of extra charges on steel angles, sectional material, rounds, squares, and hexagons. Regarding carbon, where stipulated without tensile tests being specified, over .25 up to and including .30 per cent., the extra charge is 10s. per ton; over .30 up to and including .35 per cent., 15s per ton; over .35 up to and including .40 per cent., 20s. per ton. There is nothing doing in the steel trade at Barrow, and the whole of the works are standing idle. Prospects in this trade, in common with all allied industries, are about as bad as they could possibly be. Railway material is being rolled at Workington Ship-plates for Barrow shipbuilders continue to arrive from South Wales. The Barrow Hoop Works were working last week. Last week the North East Coast steelmakers announced further drastic reductions in quotations, which are attributed to the recent fall in hematite prices, and are as follows:—Steel boiler plates to £25, steel ship bridge and tank plates from £21 to £19; steel angles and sections from £19 10s. to £17 10s., steel joists from £19 to £17 10s. A similar policy has been adopted in the Scottish steel industry, steelmakers intimating a reduction of £2 per ton in ship-plates and angles, and £3 in boiler plates, for home delivery. A joint meeting of representatives of the South Wales Siemens Steel Association and members of the Iron and Steel Trades Confederation has been held at Swansea, to discuss the question of the process men coming under the sliding scale arrangement, whereby wages are regulated by the price of steel bars which principle has already been agreed to by the Welsh tin-plate trade and certain sections of the South Wales steel trade. The meeting decided to put the sliding scale in operation. On the ascertainment of prices of steel bars for October, November, and December last, the scale comes into operation with a percentage of 156.25, and the employers agreed that where the base rate for a normal week shall be 30s. per week or under, an additional bonus of 10 per cent. shall be paid until December 31 of this year.

SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

SPECIAL STEEL FOR CONSTRUCTIVE PURPOSES.

The STEEL COMPANY OF SCOTLAND, Ltd.

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PLATES, BARS, RAILS and JOISTS.

In Soft, Mild, Medium, High Tensile, H H Tensile, Nickel and Alloy Steel.

DALZELL STEEL
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FOR EVERY TYPE OF FURNACE.

Steel Moulders' Composition.
SUITABLE FOR ALL WEIGHTS AND DESCRIPTIONS OF STEEL CASTINGS.

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MANUFACTURERS OF HIGH-CLASS REFRACTORY GOODS.
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SPECIALITIES:—
RAILS, TRAM RAILS, STEEL SLEEPERS, STEEL JOISTS to 24 in. deep.
CHANNELS, ANGLES, BARS, SHEARED PLATES, FLITCH PLATES to 36 in wide, &c.
BRIDGEWORK and CONSTRUCTIONAL IRONWORK.
SPECIAL STEEL CASTINGS. ROLLING STOCK.

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Finished Iron.

With practically a cessation of works activity in all the chief centres of the industry the current week has been mainly devoted to holiday making, with perhaps an occasional exception where urgent orders were in hand. Marked bar makers have still a fair amount of work on their order books, but in the case of crown qualities the position is entirely reversed, the competition experienced from Continental mills having had a serious effect upon this branch of the industry. This is perhaps more severely felt in South Staffordshire, where nut and bolt makers have participated in the advantage, purchasing raw material in the cheaper markets offered by France, Belgium and Germany. It is currently reported in South Staffordshire that crown bars have changed hands at a £2 cut under Association prices, but however that may be, the demand is so restricted that no very important transactions have materialised, even at these values. There is only a moderate inquiry at present for iron strip and hoops, the latter having been marked down £2 per ton. Scottish malleable bar iron makers are now in a position to counter the competition of bars of Belgian origin, inferior qualities of which, offered at very low prices, would not have been bought in normal times for many purposes for which they are now being used. At Sheffield foundries are quiet, and there is now no scarcity of castings.

Tinplates.

Though without material change the tinplate market disclosed somewhat more favourable conditions, stimulated, doubtless, by an increasing volume of overseas inquiry, and by the prospect of an early reopening of trade with Russia. In view of the holidays, however, substantial business was, of course, impracticable, but with more interest taken in stock plates and wasters, makers were more disposed to holding back than has been the case of late. Regarding primes, the price is unchanged at 25s. for the basis make f.o.t., whilst for plates to be made the quotation ranges up to 30s. per box, also f.o.t. Makers, however, contend that tin bars must come down in price if production costs are to be lessened, and in this respect it is stated that with Welsh bars still maintained at £14 10s., represents 34s. basis as the price of tinplates. Outside the Association, bars are being sold at less than £14 10s., whilst there is a fairly considerable quantity of French and Belgian bars at still lower quotations coming over to South Wales.

Refractories.

The refractories market shows little indication of change this week. Business, so far as steelworks' requirements are concerned, is very dull. Makers have large stocks of silica bricks, and most works are now working short time.

Consequent upon the slackness of the steelworks, the demand for magnesite bricks, pea size, and cement magnesite has fallen very considerably. The difficulties experienced by manufacturers in the past year in supplying the demand for this class of refractory can now be regarded as over. Supplies of excellent quality raw material are now coming into the country regularly, and manufacturers are holding good stocks and can supply requirements promptly. Similar remarks apply to chrome bricks and chrome ore.

The demand for cupola ganister and moulding sands, etc., for iron foundries is still well maintained. The steel foundry branch of the trade is slack, many foundries working short time, have sufficient stock of sands and compositions to last some time.

The crucible steel trade in Sheffield and district shows no improvement yet. Manufacturers of refractory materials are unable to make any further reductions in prices, and the current quotations are round about the figures quoted in our previous issue, though for materials of which large stocks are in hand easier terms are quoted occasionally, and especially to firms who are prepared to place firm orders or contracts for supplies.

Furnace Coke.

An outstanding feature of the pig-iron trade last week was the welcome fall in the price of coke. The coke makers of Durham have hitherto had a price agreement, by which selling prices were fixed in the same way as the local ironmasters fix pig iron prices. The effect has undoubtedly been to stiffen prices on a falling market, and until this week the total extent of the fall in blast-furnace coke was no more than 8s. 3d. per ton. But subsequently the price agreement was broken, coke makers being left free to arrange their own terms, and as a result business had been done in blast-furnace coke as low as 42s. 6d. per ton, as against 54s. 6d. at the ovens, which was the ruling figure previously.

Metals.

Copper.—The prevailing tendency in last week's market was distinctly firmer, with values on the upgrade, but in view of the holiday interruption the actual business transacted was only of moderate volume. There can, however, be little doubt that consumers are coming forward again, but demand meanwhile has not realised expectations as far as the home market is concerned. Advices from the States report a little improvement in copper, and this has had a steadying effect upon markets on this side, markets closing firm, with standard metal showing an advance in both positions.

Tin.—Cables reporting idle conditions in the East, the market for tin on this side was again quiet, but with a firmer tone. The New York market was reported as strong for forward deliveries, though the values ruling there are distinctly low compared to prices here and the East.

Spelter.—The market was quiet, with business done at £26 10s. for June, and £26 15s. for July, the market closing with further buyers at the latter price, while the nearest value for March was £25 10s. English, £28 10s.; electro, 99.9 per cent., £33 10s.

Lead.—There has been a little more activity in this market, with a good inquiry for June, which changed hands at £19 15s., while carrying from April to July was done at 10s. and from April to June at 7s. 6d. contango.

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Metal Brokers, Mineral Agents, and Carriers.
BRIERLEY HILL, STAFFORDSHIRE.

SUPERIOR SILICA BRICKS
FINE SILICA CEMENT.
TRADE MARK— R. DINAS.
H. & H. E. SMART KIDWELLY.

DO YOU REQUIRE CASTINGS From 1 cwt. to 2 tons each?
The NORTHGATE IRONWORKS Co.
(Proprietors, R. Boby, Ltd., Associated with Vickers, Ltd.),
RAIL SIDING, BURY ST. EDMUNDS, SUFFOLK.
Finest Modern Foundry in the Eastern Counties.
Speciality: MACHINE MOULDING.
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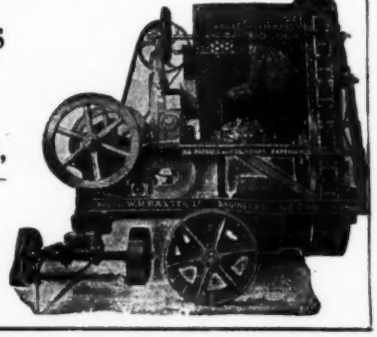

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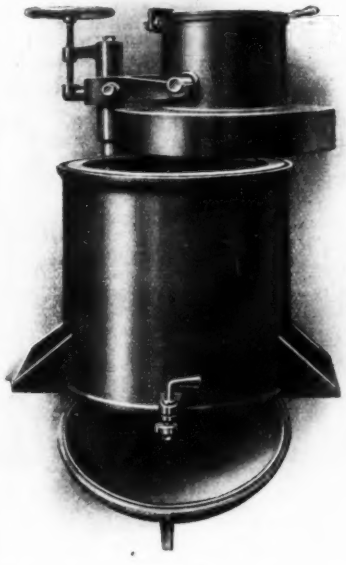
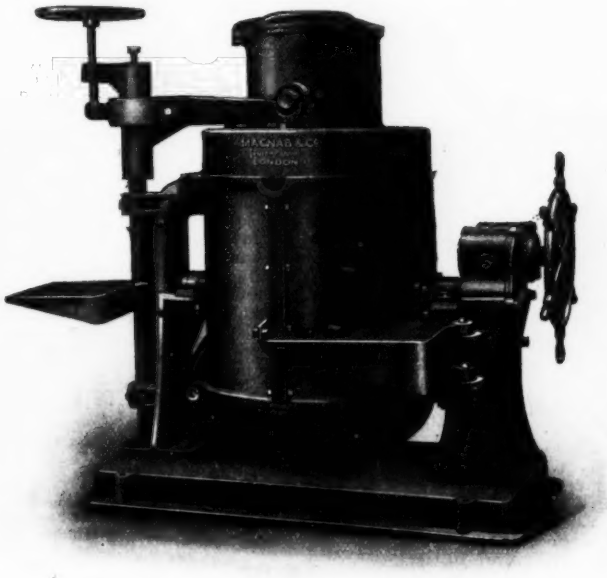
Reduce your fuel cost! **Melt in a hurry!**





Tylor Patent Pit-Type Furnace.

OUTPUT.
200 lbs. Admiralty Gunmetal melted in 35 minutes. Temperature 2000° F.=1093° C.

ECONOMY.
25 lbs. of Coke used per 200 lbs. of Metal melted.

STANDARD CRUCIBLES.
Lasting 35 to 40 heats.

Tylor Patent Tilting-Type Furnace.

OUTPUT.
450 lbs. Admiralty Gunmetal melted in 50 minutes. Temperature 2000° F.=1093° C.

ECONOMY.
80 lbs. of Coke used per 450 lbs. of Metal melted.

STANDARD CRUCIBLES.
Lasting 30 to 40 heats.

56/8, EAGLE STREET, SOUTHAMPTON ROW, LONDON, W.C.1.

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WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	69	12	6
Three months	69	2	6
Electrolytic	71	10	0
Tough	69	10	0
Best selected	70	0	0
Sheets	114	0	0
India	114	0	0
Wire bars	71	10	0
Do. April	71	10	0
Do. May	71	10	0
Ingot bars	71	10	0
H.C. wire rods	80	0	0
Off. aver. cash, Feb.	71	0	9
Do. 3 mths., Feb.	70	14	10½
Do. Settlement Feb.	71	0	4½
Do. Electro. Feb.	76	15	6
Do. B.S., Feb.	75	1	10½
Aver. spot, copper, Feb.	71	0	0
Do. Electro. Feb.	77	12	6
Solid drawn tubes		15½d.	
Brazed tubes		15½d.	
Wire		12d.	
Yellow metal rods		9d.	
Do. 4x4 Squares		11d.	
Do. 4x3 Sheets		11d.	

BRASS.

Solid drawn tubes	13¾d.
Brazed tubes	16¾ l.
Rods	12⅝ l.
Sheets to 10 w.g.	12¼ l.
Wire	12⅛ l.
Rolled metal	11¾d.

TIN.

	£	s.	d.
Standard cash	161	10	0
Three Months	165	0	0
English	162	0	0
Bars	164	0	0
Chinese	158	10	0
Straits	173	0	0
Australian	172	0	0
Eastern	167	5	0
Banca	180	0	0
Off. aver., cash, Feb.	166	9	1½
Do. 3 mths., Feb	170	16	3
Do. Sttlment. Feb.	166	6	6
Aver. spot, Feb.	166	5	3

SPELTER.

	£	s.	d.
Ordinary	25	5	0
Remelted	22	0	0
Hard	19	15	0
Electro 99.9	33	10	0
English	28	10	0
India	22	15	0
Prime Western	26	5	0
Zinc dust	57	10	0
Zinc ashes	6	5	0
Off. aver., Feb.	25	5	5½
Aver., spot, Feb.	22	17	0

LEAD.

	£	s.	d.
Soft foreign ppt	20	2	6
English	21	10	0
Off. average, Feb.	21	0	0
Average spot, Feb.	20	13	7½

ZINC SHEETS.

	£	s.	d.
Zinc sheets, spot	36	0	0
Do. V.M. ex. whf	37	0	0
Do. ppt., f.o.b., N.Y.		—	
Dutch	36	0	0
Boiler plates	34	0	0
Battery plates	33	10	0

ANTIMONY.

	£	s.	d.
English regulus	37	5	0
Special brands	42	0	0
Chinese	23	10	0
Crude	19	5	0

QUICKSILVER.

	£	s.	d.
Quicksilver	12	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
45/50%	£18 0 0
75%	£25 10 0
Ferro-vanadium—	
35/40%	25/- lb. va.
Ferro-molybdenum—	
70/80%	10/6 lb. mo.
Ferro-titanium—	
23/25%, carbonless	1/6 lb.
Ferro-phosphorus, 20/23%	£33
Ferro-tungsten—	
80/85%, carbon free	1/10 lb.
Tungsten metal powder—	
98/99%	2/4 lb.
Ferro-chrome—	
4/6% car.	£37 10
6/8% car.	£37
8/10% car.	£36 0
Ferro-chrome—	
Max. 2% car.	£84
Max. 1% car.	£100
Max. 0.75% car.	£115
65/75%, carbonless	2/10 lb.
Nickel—99·8% cubes or pellets	£200
Cobalt metal—97%	19/6 lb.
Aluminium—98/99%	£150
Metallic Chromium—	
98/99%	6/6 lb.
Ferro-manganese—	
76/80%, loose	£25
76/80%, packed	£26
76/80%, export	£22 10
Metallic manganese—	
98/99%, carbonless	3/1 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	s. d. 3 2
Finished bars, 18% tungsten	4 0
Scrap pieces	5d.
Turnings and swarf	3d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. to 8 in. inclusive	4d. lb.
Rounds and squares under ½ in. to ¼ in.	3d. lb.
Flats under 1 in. by ⅜ in. to ¼ in. by ¼ in., and all sizes over four times in width over thickness	3d. lb.
Bevels of approved sizes and sections	6d. lb.
If in coils	3d. lb.
Packing	4s. cwt
Bars cut to length	10% extra

Scrap from high-speed tool steel—

Scrap pieces	5d.
Turnings and swarf	3d.

Per lb. net, d/d steel makers' works.

SCRAP.

South Wales	£	s.	d.
Heavy Steel	4	0	0
Bundled steel & shearings	4	0	0
Mixed iron & steel	1	10	0
Heavy cast iron	4	10	0
Good machinery for foundries	5	0	0
	7	10	0

Cleveland—			
Heavy steel	3	5	0
Steel turnings	2	10	0
Cast-iron borings	2	10	0
Heavy wrought iron piling	5	15	0
Bundling scrap	5	5	0
Cast-iron scrap	7	0	0

Lancashire—			
Cast iron scrap	7	0	0
Heavy wrought	4	10	0
Steel turnings	2	10	0

London—			
Copper (clean)	53	0	0
Brass (clean)	30	0	0
Lead (less usual draft)	14	0	0
Tea lead	12	0	0
Zinc	12	0	0
New aluminium cuttings	70	0	0
Braziery copper	43	0	0
Gun metal	50	0	0
Hollow pewter	110	0	0
Shaped black pewter	65	0	0

PIG-IRON.

N.-E. Coast—	
Foundry No. 1	155/-
Foundry No. 3	150/-
Forge No. 4	147/6
Mottled	147/6
Hematite No. 1	182/6
Hematite M/Nos.	180/-

Midlands—	
Staffs. common	145/-
„ part-mine forge	160/-
„ „ foundry	170/-
„ Cold blast	350/-
„ basic	140/-
Northants forge	140/-
„ foundry No. 3	160/-
„ basic	140/-
Derbyshire forge	160/-
„ foundry No. 3	170/-
„ basic	160/-

Scotland—	
Foundry No. 1	175/-
„ No. 3	170/-
Hematite M/Nos.	185/-

Sheffield (d/d district)—	
Derby forge	165/-
„ foundry No. 3	170/-
„ basic	165/-
Lincs. forge	165/-
„ foundry No. 3	170/-
„ basic	162/6
E.C. hematite	193/-
W.C. hematite	196/-

All d/d in the district.

Lancashire (d/d eq. Man.)—	
Derby forge	—
„ foundry No. 3	180/-
Northants foundry No. 3	—
Cleveland foundry No. 3	—
Staffs. foundry No. 3	—
Lincs. forge	172/6
„ foundry No. 3	177/6
Summerlee foundry	199/-
Glengarnock foundry	199/-
Gartsherrie foundry	199/-
Monkland foundry	199/-

FINISHED IRON & STEEL.

Iron—	£	s.	£	s.	d.
Bars (cro'n)	20	0	24	10	0
Angles	20	10	25	0	0
Tees to 3 united ins.	21	0	25	10	0
Nut and bolt			22	0	0
Hoops			23	0	0
Marked bars (Staffs.)			27	10	0
Gas strip			26	0	0
Bolts and nuts, ⅜ in. × 4 in.			42	0	0

Steel—			
Ship plates	19	0	0
Boiler plates	25	0	0
Checquer plates	22	0	0
Angles	17	10	0
Tees	18	10	0
Channels	18	0	0
Joists	17	10	0
Rounds, ⅜ in.–3-in.	17	0	0
Rounds, 3 in.–5½ in.	16	0	0
Flats, 5 in.–8 in.	16	10	0
Flats over 8 in.	16	0	0
Rails, heavy	18	0	0
Fishplates	23	0	0
Hoops	18	10	0
Black sheets, 24 g.	23	0	0
Galv. cor. sheets, 24 g.	24	0	0
Galv. fencing wire, 8 g. plain	30	0	0
Rivets, ¾ in. dia	30	0	0
Billets, soft	13	10	0
Billets, hard	14	10	0
Sheet and tin bars	14	10	0

PHOSPHOR BRONZE.

Rolled.	Per lb. s.	d.
½ in. to 1 in. wide	1	11½
1 in. to 1½ in. wide	1	10½
1½ in. to 2 in. wide	1	9½

Strips.	s.	d
2 in. to 6 in. to 26 S.W.G.	1	8¾
6 in. to 12 in. to 26 S.W.G.	1	8¾

Sheets.	s.	d
12 in. to 18 in. to 24 S.W.G.	1	9
18 in. to 24 in. to 24 S.W.G.	1	9¼
24 in. to 30 in. to 20 S.W.G.	1	10¾
30 in. to 36 in. to 16 S.W.G.	1	11¼
36 in. to 42 in. to 16 S.W.G.	2	0¼

Extras.

For Gauge: Any width up to 36 in. wide, ¼d. per lb. per thinner gauge.

Drawn Rods.	s.	d.
¼ in. to ⅜ in. dia. in random lengths / ⅜ in. to 1¼ in. dia. in random lengths	1	9½
Over 1¼ in. to 1⅝ in.	1	9½
Tubes—basis price	1	11½

Delivery 2 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

Charles Clifford & Son, Limited, Birmingham.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	1/3 to 1/9
Rolled—	
To 9 in. wide	1/10½ to 2/4½
To 12 in. wide	1/11 to 2/5
To 15 in. wide	2/- to 2/6
To 18 in. wide	2/1 to 2/7
To 21 in. wide	2/2 to 2/8
To 24 in. wide	2/3 to 2/9
Ingots for spoons and forks	1/3 to 1/9
Ingots rolled to spoon size	1/6 to 2/-
Wire round—	
3/0 to 10. G.	2/1 to 2/8

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	27.84
No. 2 foundry Valley	26.00
No. 2 foundry, Birm.	25.00
Basic	27.26
Bessemer	28.96
Malleable	26.00
Grey forge	26.96
Ferro-manganese 80 % delievred	90.00
Bess. rails, h'y, at mill	45.00
O.-h. rails, h'y, at mill	47.00
Bess. billets	38.50
O.-h. billets	38.50
O.-h. sheet bars	40.00
Wire rods	52.00
	Cents.
Iron bars, Phila.	2.70
Steel bars	2.00
Tank plates	1.90–2.10
Beams, etc.	2.10
Skelp, grooved steel	2.35
Skelp, sheared steel	2.50
Steel hoops	2.80
Sheets, black, No. 28	3.85
Sheets, galv., No. 28	5.00
Sheets, blue an'l'd, 9&10	3.00
Wire nails	3.00
Plain wire	3.00
Barbed wire, galv.	3.85
Tinplate, 100-lb. box	$7.00

COKE.

Welsh foundry	72/6
„ furnace	57/6
Durham & North foundry	70/-
„ furnace	42/6
Other Districts, foundry	77/9
„ furnace	45/-

SWEDISH IRON.

Bars, hammered basis sizes ..	Basis price.	
Rolled Ordinary— Assortment ..	£ s. d.	
Nail Rods— Square, round and flats ..	31 0 0 to 38 0 0	
Keg Steel / Faggot Steel	about £50	Prices nominal.
Blooms— Single welded ..	£20 to £25	
Billets— Single and double welded ..	£22 to £27	
Pig-Iron— Grey, white or mottled ..	£15 to £20	

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

TUBES.

	Up to and incl. 2 in.	Over 2 in.
Gas ..	−10%	−15%
Water ..	net	+ 6¼%
Steam ..	+11¼%	+ 3¾%

REFRACTORIES.

	£ s. d.
Magnesite bricks, 2½ in., d/d	130 0 0
Do. 3 in., d/d	156 0 0
Common firebricks, 2½ in., d/d	10 0 0
Do. 3 in., d/d	12 0 0
Scotch firebricks, 2½ in., f.o.r.	12 15 0
Do. 3 in., f.o.r.	15 7 6
Sheffield quality, 2½ in., f.o.r.	11 0 0
Do. 3 in., f.o.r.	13 5 0
Silica bricks (ord.), 2½ in., f.o.r.	14 18 6
Do. 3 in., f.o.r.	17 18 6

All per 1,000 bricks.

Basic Dolomite ..	3 18 0
Dead burnt magnesite (peas and powder), d/d ..	22 10 0
Ground fireclay	1 10 0 to 2 0 0
Ganister	1 10 0 to 1 12 6

TINPLATES.

I.C. Cokes, 20×14, box	25/-
„ 28×20, „	52/-
„ 20×10, „	37/-
„ 18¾×14, „	29/-
Terneplates, 28×20, „	55/-

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£ s. d.	
Mar.23	69 0 0	inc. 20/-
„ 24	69 7 6	inc. 7/6
„ 25	—	—
„ 28	—	—
„ 29	69 12 6	inc. 5/-

Standard Tin (cash).

Mar.23	160 5 0	inc. 65/-
„ 24	165 10 0	„ 105/-
„ 25	—	—
„ 28	—	—
„ 29	161 10 0	dec. 80/-

Zinc Sheets (spot).

Mar.23	36 0 0	No change
„ 24	36 0 0	No change
„ 25	—	—
„ 28	—	—
„ 29	36 0 0	No change

Spelter (ordinary).

Mar.23	25 10 0	inc. 10/-
„ 24	25 10 0	No change
„ 25	—	—
„ 28	—	—
„ 29	25 5 0	dec. 5/-

Lead (English).

Mar.23	20 10 0	inc. 5/-
„ 24	21 10 0	No change
„ 25	—	—
„ 28	—	—
„ 29	21 10 0	No change

SHROPSHIRE IRON Co., Ltd.

Works — Hadley, Shropshire.

London: 10, Bush Lane, Cannon St., E.C.4.

Telegrams:— Sun, Wellington, Salop. Sunbrand (Cannon), London.

Telephone:— 11 Wellington, Salop. 5959 Central.

BARS, HOOPS, SECTIONS & WIRE
in IRON, STEEL, COPPER and BRONZE.

Galvanised Telegraph, Telephone, Cable and Trolley Wire
To all Specifications.

Contractors to H.M. Government (Admiralty, G.P.O., India Office, War Office, Colonies), English and Foreign Railways, &c.

BEST H. C. COPPER & BRONZE WIRE a speciality.

Medals:—Sydney (Bronze) 1879, New Zealand (Gold) 1882, Liverpool (Silver) 1886, Adelaide (Gold) 1887, Franco-British Grand Prix (Highest Award) 1908.

ROBERT HEATH & LOW MOOR, LIMITED, Stoke-on-Trent.

B.B.H. IRON.
At works.
BARS, ANGLES, TEES and PLATES.

R.H. ☆ IRON.
Delivered F.O.B. Liverpool, BARS, ANGLES, TEES and PLATES.

HOOPS delivered F.O.B. Liverpool.

IRON
R.D. ☆
RAVENSDALE (Best)

MILD STEEL (up to 2in. wide) Marked "HEATH'S SOFT STEEL."

Prices on Application.

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Telegrams: ALKALIZE, BIRMINGHAM.
Telephone: CENTRAL 1175 & 1176
Birmingham Office:
18, BENNETT'S HILL.

Telegrams: ALKALIZE, LONDON.
Telephone: 7860 AVENUE (3 lines.
Head Office:
5, EAST INDIA AVENUE, London, E.C.

REGISTERED TRADE MARK

PIG IRON.

Scotch, Middlesbro,' Hematite, Basic, Specials, &c., &c.

TIN — SPELTER — CHROME
COPPER — ANTIMONY—MANGANESE.

WILLIAM COLVIN & COMPANY,

ROYAL EXCHANGE, MIDDLESBROUGH.

93, HOPE STREET, GLASGOW.

SITUATIONS VACANT AND WANTED.

GENERAL MANAGER, of large modern Foundry in Glasgow, resigning end of March, wishes appointment to represent Foundry for the district of Glasgow and the West of Scotland. Excellent connections with all leading firms requiring castings. Can obtain orders for all classes of work. Thoroughly practical.—Reply, Box 726, Offices of the Foundry Trade Journal, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

JOURNEYMAN MOULDER, at present disengaged, desires post; Midlands preferred.—Box 720, Offices of the Foundry Trade Journal, Bessemer House, 5, Duke Street, Adelphi, Strand, London, W.C.2.

FOREMAN PATTERNMAKER (40), desires re-engagement; good organiser and controller. Exp. Motor, Marine, Cent. Pumps, and Loam.—Box 722, Offices of the Foundry Trade Journal, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

WANTED.—Foundry Foreman, possessing thorough knowledge all types Moulding Machines, as well as good General Foundry Experience, for Midlands.—Apply in writing, Geo. C. Usher, Coventry House, South Place, London, E.C.2.

MACHINERY.

TURN TO THE B.W.S. ANNOUNCEMENT, PAGE 12.

KEITH-BLACKMAN EXHAUST or BLOWING FAN, 10 in. inlet and outlet, direct coupled to a 5-h.p. twin-opposed horizontal two-stroke Lewis Petrol Motor, new; STURTEVANT BLOWER, 7 in.; GUNTHER ditto, 8 in.; LLOYD'S ditto, 12 in.; SCHIELE ditto, 12 in. Gunther-type EXHAUST or BLAST FAN, 36 in. rotor, in all steel plate volute case, inlet 30 in. dia., outlet 14 in. by 16 in., with cast-iron chair attached carrying bearings and pulley between, and very high class; all overhauled, repainted, and guaranteed as new.—J. Booth & Son, Congleton. 'Phone 114.

NEW FLETCHER, RUSSELL Melting Furnace (forced draught or high-pressure gas) 400 lbs., cap, tilting type; all latest improvements; complete with crucible, etc.; cost about £200. What offers? No reasonable offer refused.—The Furnace Exchange, Croft Street Engineering Works, Preston, Lancs.

"FARWELL" HAND-SQUEEZE MACHINE Wanted.—Write, giving full particulars, to Box 724, Offices of the Foundry Trade Journal, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOR SALE.

TWENTY-FOUR MARINE TYPE SELF-CONTAINED WATER TUBE BOILERS, by Messrs. Babcock & Wilcox, Limited, varying in heating surface from approximately 1,610 to 2,813 square feet per boiler, constructed for a working pressure of 270 lbs. per square inch.

ONE LANCASHIRE BOILER, 30 ft. × 8 ft. dia., reinsure 120 lbs. pressure.

TWO CORNISH BOILERS, 28 ft. × 6 ft. dia., reinsure 90 lbs. pressure.

TWO MARINE BOILERS, 10 ft. 4 in. long × 12 ft 2 in. dia., reinsure 150 lbs. pressure.

ONE VERTICAL BOILER, 6 ft. × 3 ft. dia., reinsure 80 lbs. pressure.

ONE VERTICAL BOILER, 6 ft. 6in. × 3 ft. 9 in. dia., reinsure 80 lbs. pressure

ONE LOCO TYPE BOILER, barrel 12 ft. long × 4 ft. 8 in. dia., reinsure 160 lbs. pressure.

ONE OPEN TOP RIVETED CISTERN, 8 ft. 6 in. × 7 ft. 6 in. × 5 ft. 10½ in. deep at one end, and 5 ft. 4 in. deep at other end (average, 5 ft. 7 in. deep).

SEVERAL UNUSED SECTIONAL STEEL CISTERNS, 8 ft. × 8 ft. × 4 ft. deep, capacity about 1,600 gallons each.

SEVERAL DISHENDED CYLINDERS, each 6 ft. × 2 ft., tested hydraulically to 150 lbs. pressure

ABOUT 4,300 ft. run of Galvanised Piping, 2 in. diameter.

ABOUT 1,300 ft. run of New Cast-iron Piping, 6 in diameter.

LARGE NUMBER OF GALVANISED STEEL WIRE ROPES, each 300 ft. long × 1¼ in. circumference, thimble at one end.

CATALOGUE OF STOCK MACHINERY, 5-6,000 LOTS, FREE ON APPLICATION. INSPECTION INVITED.

THOS. W. WARD, Ltd.,
ALBION WORKS, SHEFFIELD.
Telegrams: "Forward, Sheffield."
Telephone: 4321 (8 lines).

MACHINERY—*Contd.*

MARINE BOILERS.—
FOR SALE Single-ended BOILERS, 13 ft. by 11 ft 3 in.
Three corrugated furnaces, Deighton type.
Howden's forced draught.
Working pressure 200 lbs.
First-class condition as practically new, and Lloyds will accept as new from instalment.
Apply, Robinson Brown & Company, Newcastle-on-Tyne

MISCELLANEOUS.

FOR SALE.—Wood Sectional Huts, weatherboard and lined:—
Twelve 60 ft. by 15 ft., f.o.r., at £150 each.
Four 109 ft. by 15 ft., f.o.r., at £200 each.
Four 82 ft. by 15 ft., f.o.r., at £180 each.
One 102 ft. by 15 ft., f.o.r., at £190 each.
One 78 ft. by 15 ft., f.o.r., at £170 each.
One Corrugated Iron and Wood Building, divided several rooms, lined, and good wood floor, 190 ft. by 28 ft. in place, £350.—Joseph Thompson, Engineering Contractor, Wilton, Wilts.

ORDERS WANTED for small Machine-made Castings in Brass, Gunmetal, Phosphor, or Manganese Bronze. Also Castings any size up to one ton in weight. Prompt delivery.—James G. Crowther, Paradise Street Brass Foundry, Sheffield.

WANTED to Purchase, Surplus Stocks of Valve Stampings in the following steel specifications: K.8, K.9, S.19, and 3 per cent. nickel.—State size, price and quantity to Box. 714, Offices of the Foundry Trade Journal, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

40,000 HIGH GRADE STEEL BLANKS: 3 in dia. × ⅞ in. thick × ¾ in. hole; 3⅞ in dia. × ⅝ in. thick × ⅝ in. hole; 4½ in. dia. × ⅝ in. thick × ¾ in. hole. Price 20s. per cwt. Samples free.—B.E. Co., 304, High Holborn, London, W.C

WANTED all users of METALLIC CEMENT to buy our PEERLESS brand, which produces "Artificial Iron" 10 lb. tin 10s., free delivered.—William Olsen, Ltd., Cogan Street, Hull.

FOR SALE, cheap, Foundry Pig Iron, all sections, F.B. Steel Rails, with all accessories; Joists, Channels, Angles, Sheets and Plates, all thicknesses; plumbago.—Ascog, Golder's Green, London. Telephone; Hampstead, 1806.

WE Specialise in FANS and FAN WORK for Foundries. H.P. Fans and Blowers for Smiths' Hearths, Cupolas, Oil and Gas-fired Furnaces, Dust Extraction Fans for Fettling Shop and Sand Blast, Ventilating Fans for Fumes, etc. Worm-geared Pulley Blocks, 10 cwt. to 10 tons.—Progressive Engineering Company, Limited, Leicester.

PATTERN MAKING, wood and metal for engineers, motor, and other trades; keen prices, accurate work, and quick delivery.—The Rolfe Patern Making Company, 105, Rolfe Street, Smethwick

ENQUIRIES SOLICITED FOR CASTINGS IN IRON, machined or unmachined, up to 5 cwt. Complete Machines built throughout to specification, singly or in quantity. Jig and Tool Work a speciality.—C. S. Peatfield, Limited, Market Rasen, Lincs.

PATTERNS and CASTINGS SUPPLIED WHICH GIVE SATISFACTION. Inquiries solicited. Quotations by return of post or telephone. You can secure good-class work, reasonable prices, and promptitude in delivery by placing your orders with Videx Pattern Works and Foundry, Huntsworth Mews, Upper Baker Street, London, N.W.1. (Telephone, Paddington 364).

BUCKINGHAM BROS., Metal and Wire Workers, Warwick Road, Luton. Makers of Moulders' Sieves and Riddles. New bottoms put in old rims. Please send for quotation.

PATENTS.

ADVICE and Handbook Free. — King's Patent Agency, Limited, Director, B. T. King, Reg. Patent Agent, 146a, Queen Victoria Street, E.C.4.

THE PROPRIETORS of the Patent No. 3,786, of 1915, for Heat Treatment of Manganese Steel, are desirous of entering into arrangements, by way of licence and otherwise, on reasonable terms, for the purpose of exploiting the same and ensuring its full development and practical working in this country.—All communications should be addressed in the first instance to Haseltine, Lake & Co., Chartered Patent Agents, 28, Southampton Buildings, Chancery Lane, London, W.C.